JOURNAL

OF THE

RUBBER RESEARCH INSTITUTE OF MALAYA

VOL. 4 NOVEMBER, 1932. No. 2

EDITORIAL.

FURTHER NOTES ON SHEETING BATTERIES.

Considerable interest in sheeting batteries has been shewn during recent months and, as a result, several designs of continuous sheeting batteries have appeared on the market. The advisory work of the Institute in this direction has, however, been devoted chiefly towards modernising existing plant by adapting old-type side-by-side machines and using them as units in a continuous sheeting battery. The article by Messrs. Bishop and Wiltshire therefore is decidedly opportune and will go far to explain the relative importance of the various factors involved. Emphasis is laid on the importance of the uniformity and softness of the coagulum and it is stressed that these are the controlling factors, without due notice of which good results are not likely to be obtained. The results of adapting old type machines have been quite successful and this article will prove of the greatest utility to other estates which may, in the future, decide to rearrange their factory plant.

SULPHURIC ACID AS LATEX COAGULANT.

The importance of bringing factory costs to the lowest possible level is fully realised at the present moment by all engaged in the rubber industry and any avenue likely to lead in the proper direction is thoroughly explored. When a well-known method is definitely cheaper and equivalent results can be obtained as compared with other methods, there is generally some unusual factor

or factors which prevent wide acceptance. In the case of coagulation by Sulphuric Acid the obvious factor is the danger which arises from careless handling. If careful handling can be ensured, and the minimum quantity of diluted acid necessary for coagulation is added to the latex, it is shewn that coagulation with Sulphuric Acid will give entirely satisfactory results. But the proviso made by Dr. Wiltshire in the last paragraph of the article should be given full consideration.

(a) Effect of Meteorological Factors on the Virulence of Oidium Heveae in Malaya.

(b) Report on Sulphur Dusting Experiments.

The two articles by Mr. Beeley bring up-to-date the work done in Malaya on the life-history and control of *Oidium Heveae*. The present position may not seem unsatisfactory but there are important reasons why this problem should receive further attention. Recently several visitors from Java have made the same comment when comparing the density of foliage of the rubber trees in Java and Malaya; the leaf canopy in the former is much more sparse than in the latter country and this perhaps accounts to some extent for the smaller yields obtained in countries outside Malaya which are troubled with *Oidium Heveae* on rubber plantations. The writer cannot vouch that the above truly represents the position in Java, but there seems litle doubt in the minds of planting visitors that *Oidium Heveae* has caused permanent damage to the plantations where treatment has had to be undertaken. A prominent member of the planting community in Malaya, who is familiar with the conditions in Malaya, Java and Sumatra, affirms that a similar operation has begun in certain parts of Malaya i.e., that foliage has become and is in process of becoming more and more sparse and that decreased yields may be expected in the future from such areas. This phenomenon he attributes to the constant presence of *Oidium Heveae* in the plantations even if it is not often conspicuous. One feature can be fairly definitely stated viz. *Oidium Heveae* can usually be found growing on the flower stalks in Malayan plantations and the decrease in seed yield during recent years may largely be accounted for in this way. Again it is of interest to note that the point of major importance in a question of declining yields on old rubber may be a purely pathological problem and not necessarily a cultivation problem.

The sulphur dusting experiments, unfortunately, could not be carried out thoroughly to completion, but sufficient experience was obtained to overcome many technical difficulties.

On the Effect of Covers and Cultivation Methods on the Growth of Young Rubber. III.

The Carbon and Nitrogen Contents of some Natural Covers.

The blocks under experiment at the Experimental Station, Sungei Buloh, are now beginning to give interesting information in respect of growth records. Under existing conditions at Sungei Buloh, it has been definitely established that some cover crops do compete with the rubber trees in their quest for supplies of nutrient material and that, in general, this results in a retardation of growth of the rubber trees. It appears that Lamtoro (*Leucaena Glauca*) has definite advantages over Calopogonium and Crotalaria and that the effects of competition between the rubber trees and the cover can be ameliorated by digging or pulling out the cover crop. The growth results from the belukar blocks bring very undoubted evidence that the ultimate effect of allowing free growth of belukar is to cause severe retardation in growth; it is perhaps surprising that delay in development does not become apparent at an earlier stage. Another noteworthy feature is that trees which suffered a prolonged delay in the early stages of growth have ultimately developed into normal looking trees; evidently they possessed the ability to overcome early handicaps. At one time, there was some discussion as to the choice of a site for experimental work other than the present one because the trees were so definitely backward in growth.

The article by Mr. Ackhurst dealing with the Carbon-Nitrogen ratios in commonly grown leguminous and non-leguminous covers is of general interest in focussing attention upon the relative value of these plants in-so-far as nitrogen is replaced in the soil by their final decay. It will be seen that rubber seedlings are almost as useful in this respect as the legumes Calopogonium and Centrosema, a figure of 4.23 per cent N as against 4.47 per cent N and 4.38 per cent N respectively.

The Properties of Clone Rubber.

This article is the first of a series which should become of increasing importance. There is very little doubt that concentrated research on tapping systems will be required as increasing quantities of bud-grafted rubber come into bearing in the future, for a tapping system suitable for one clone is very unlikely to prove suitable for all other clones. In the same way, investigations on the chemical and physical properties of rubber from various clones

may disclose differences which will necessitate different treatments. The subject opened up by this article, is an extremely wide one and cannot profitably be pursued at the present moment.

Variability of Sheet Prepared under Laboratory Conditions.

The note on the variability of sheet prepared under laboratory conditions brings forward evidence that a satisfactory check on the degree of standardisation of the coagulation and making of batches of sheet can be obtained by a study of (a) the water content of the machined wet sheet and (b) the area of the finished dry sheet.

Quebrachitol and the Lipin from Hevea Latex.

The notes on Quebrachitol and Lipin from Hevea Latex were received from Dr. Woodman who carried out this work in England. While of no immediate practical importance it is interesting to note that the work resulted in the first record of dual types of emulsion from a certain oil being present in the same system at one and the same time.

Kuala Lumpur, F.M.S., 30th November, 1932.

FURTHER NOTES ON SHEETING BATTERIES.

BY

R. O. Bishop and J. L. Wiltshire.

The output and efficiency of estate sheeting batteries has been discussed at some length by Rhodes and Bishop in this Journal in April 1931 and by Bishop in his R.R.I. Planting Manual No. 3. The advisory work which has been carried out in recent months has shown that estates are paying a great deal of attention to this question and that the general standard of efficiency is undoubtedly improving.

Our collaboration with those responsible for running estate factories has resulted in the exchange of much useful information. It is clear however that the relative importance of the various factors is not generally appreciated. In these notes we have therefore attempted to classify the fundamental features of the process and to report the various experiments and methods of calculation which we have used to demonstrate and disentangle the factors which affect efficiency.

1. *Efficiency of Machining.*

It is often useful to be able to express the efficiency of the actual machining process as a simple percentage and such a figure is easily obtained from the ratio of the speed of the sheet leaving any pair of rolls to the speed of any point on the circumference of these rolls. In practice it is given by the following formula:

$$\text{Efficiency} = \frac{1 \times 60}{r \times t \times d \times 3.14} \times 100$$

where l = length of sheet issuing from machine, in inches

t = time for passage of this length of sheet, in seconds

r = speed of rolls, in revolutions per minute

d = diameter of rolls in inches.

For example, on a six inch roll machine, turning at 40 revolutions per minute, it was found that a sheet 27 inches in length was turned out in 6 seconds.

$$\text{Hence Efficiency} = \frac{27 \times 60}{40 \times 6 \times 6 \times 3.14} \times 100$$

$$= 36\%$$

This figure is often referred to as the slip figure, by which it is implied that a 30% efficiency, for instance, represents 70% slip

on the rolls. This would be true if the length measured, i.e. the final length, were the same as the length passing through the nip. Actually, however, the whole of the squeeze suffered in the nip is not permanent and after leaving the nip the resilience of the rubber causes an increase in thickness and a decrease in length and in width. Therefore the length measured is considerably less than the length passing through the nip. Hence, in the case of a 30% efficiency, the 70% wastage represents partly slip and partly recovery of the rubber after leaving the nip. The softer the coagulum the smaller the extent of this restitution and a high efficiency figure is only to be obtained by machining a soft coagulum with as little slip as possible.

If the clearance between the rolls is too great, the degree of spreading effected is too small; if it (the roll clearance) is too small the machine is being asked to effect a greater reduction in thickness than it can efficiently achieve and the result will be either torn sheet or low efficiency due to a high degree of restitution.

To obtain the best results from any battery it should be fed with the softest possible coagulum and the most efficient setting of each pair of rolls should be determined by experiment. When machining sheet on the morning following coagulation an efficiency of 40 per cent should be aimed at and should be easily obtained on the early machines of the battery. In the fourth and fifth plain roll machine the increased toughness of the rubber will have its effect and the efficiency may drop to 25 or 30 per cent. In the marking machine, where there is very little slip, efficiencies of 60 per cent are to be expected.

The influence of softness of coagulum on the efficiency of the machining process is shewn by comparative figures obtained, in the same battery, from a normal coagulum machined 18 hours after the addition of acid and from a soft coagulum machined only 2 hours after the addition of a larger quantity of acid. In each case the latex had been diluted to 1½ pounds per gallon D.R.C. and the amounts of acetic acid added were 4.2 and 6.3 cc. per gallon respectively. The sheets were passed through five smooth roll machines and each figure quoted is the mean of four experimental results.

TABLE I.

	Normal Coagulum Efficiency per cent	Soft Coagulum Efficiency per cent	Ratio of Efficiencies
Machine No. 1	42	64	.66
2	37	47	.79
3	38	51	.74
4	28	46	.61
5	23	37	.62
Thickness of final sheet ...	.125 inch	.085 inch	
Area of final sheet ...	416 sq. inches.	616 sq. inches.	

Ratio of areas	0.68
Mean Ratio of Efficiencies	0.68

These figures show how the beneficial effect of initial softness of coagulum persists right through the machining process and gives a bigger output of a thinner and more satisfactory sheet.

2. *Softness of Coagulum.*

There is no readily-available method of obtaining a quantitative statement of the hardness or softness of coagulum. In the absence of any generally applicable figure it is necessary to find a method for comparing coagula of different softness prepared for machining in the same battery. Such a figure is to be found in the thickness or the area of the sheet after machining provided that (1) each sheet is obtained from the same volume of the same bulk of latex, (2) each coagulation is carried out in vessels of the same shape and size, (3) each coagulum is subjected to the same machining treatment. Thus the effect of varying quantities of acid may be studied by coagulating a series of one-gallon lots of latex, standardised say to 1½ lbs D.R.C., each being coagulated in the same type of pan and each being machined in the same battery. The dimensions of the resultant sheets are then very fair indications of the softness of the various pieces of coagulum. In practice it will be found simpler and more accurate to measure the area of the sheet rather than the thickness. Reference to the paper on the variability of sheet prepared under laboratory conditions (this volume page 149) will show that the area figures for 24 sheets prepared under identical conditions showed a standard deviation from the mean value of only 3.9%. Under carefully controlled conditions, therefore, the area of a series of sheets may be accepted as an indication of the softness of the corresponding coagula. An example of this may be seen in the two series of efficiency figures, already quoted in Table I overpage which refer to a normal coagulum and a soft coagulum. The ratio of the average efficiency of the two operations is seen to be exactly the same as the ratio of the areas of the two sheets. This exact agreement is partly fortuitous and indicates that the degree of actual slip was also the same in each case. It is obvious that if the adjustment of the clearances was bad there could be no exact agreement between the ratio of efficiencies and the ratio of areas. These figures, however, demonstrate very strikingly how the effect of softness on efficiency is reflected in the areas of the resulting sheets.

3. *Change of dimensions of sheet on machining.*

In the control of batteries of separate machines a knowledge of the manner in which the dimensions of the sheet are altered is of little practical importance. With the introduction of continuous sheeters, however, such knowledge is essential in determining the relative speeds of the different rolls.

The table below gives a set of figures obtained in the experimental factory of the Institute. The coagulum used was obtained from overnight coagulation at 1½ lbs per gallon, but precautions had been taken to use as little acid as possible and it was rather softer than the coagulum prepared on most estates to-day. Samples were submitted to series of six, four and three machinings respectively—the last machine in each series being a marker.

TABLE II.

Dimensions of Rubber	Six Machines			Four Machines			Three Machines		
	Length Ins.	Width Ins.	Thickness Ins.	Length Ins.	Width Ins.	Thickness Ins.	Length Ins.	Width Ins.	Thickness Ins.
Entering 1st. Machine	17	9	1.3	18	9	1.25	18	9	1.25
Leaving 1st. Machine	23	11	0.5	24	11	0.5	23	11	0.5
2nd	27	13	0.212	28	13	0.207	28	13	0.198
3rd	29	14	0.142	30	14	0.138	29	13	0.161
4th	32	16	0.112	31	15	0.111	...	...	...
5th	36	18	0.082	...	...	...	...	...	...
6th	36	18	0.082	...	...	...	...	...	...

In this instance after six machines a coagulum 9 inches in width has spread to 18 inches, i.e. to twice its original width. This is a larger increase in width and decrease in thickness than is normally achieved in practice with six machines. The resulting sheet—of thickness one-twelfth of an inch—would probably possess disadvantages under the conditions in the normal type of smoke house, e.g. inconvenient size for smoking; stretching on the broties; and difficulty in handling in the packing shed. Sheet of one-tenth to one eighth of an inch is perfectly acceptable however and any modern battery of six machines that does not turn out such sheet is not working under the best conditions. Similarly with a battery of only four machines, the provision of a soft coagulum and proper setting of the rolls should result in the production of a sheet of about one eighth of an inch thick.

4. *Continuous Sheeters.*

The continuous sheeting battery, in which the question of change of dimensions is of great importance, is now becoming a common sight in Malaya and several types are available. There are four proprietary machines on the market, which have made their appearance in the following order :

(1) The Huttenbach Continuous Sheeter.
(2) The "F.E." Machine.
(3) The Shaw Machine.
(4) The Robinson Machine.

It is not within our province to discuss the relative merits of these machines and full information can be obtained from the appropriate agents. In most instances batteries can be seen in operation in Malaya. It should be understood that each of these machines can be fed either with continuous coagulum or with individual sheets.

In some cases it has been found cheaper and more convenient to modernise existing plant than to purchase an entirely new battery. A method adopted with success on some estates has been to use old-type side-by-side machines as the units of a five or six-machine continuous battery. Examples of such conversions are given in the accompanying photographs.

Figures 1 and 2 show the factory of Estate X before and after the conversion. It will be seen that the component machines are set in concrete and are further strengthened by parallel steel girders. The drive is effected by belting and wooden pulleys. An aluminium trough is fitted between each pair of machines and a water spray on each machine ensures that the sheet is continually coming into contact with clean water.

Figures 3 and 4 show the factory of Estate Y before and after conversion. The details are similar to those of "X" but here six machines are employed instead of five. In this photograph the wooden pulleys are shown more clearly.

The peripheral speed of the successive machines of a continuous battery must increase from the first to the last for two reasons (1) the increasing length of the sheet, (2) the decreasing efficiency of the rolling. For efficient working, i.e. no stretching and no piling-up between machines, the necessary condition is that the time taken for a given piece of rubber to pass is the same for every pair of rolls or, alternatively stated, that the speed with which sheet leaves any pair of rolls bears a constant ratio to the length of sheet leaving. Since the efficiency of rolling decreases as the sheet passes on it is obvious that the successive increases in roll speed must be greater than the successive increases in length of a given piece of rubber, in order to preserve this constant ratio of sheet speed to sheet length. In theory then, the required speeds of a succession of rolls may be calculated from a knowledge of the successive changes in length of a single sheet and of the corresponding efficiency figures. As an example the calculation may be performed from a set of figures obtained in the experimental factory of the Institute. A single piece of coagulum was passed through a battery of five plain and one marking machine and the successive length and efficiency figures were record-

ed. The required speeds for coupling a continuous battery may now be calculated as a ratio of the speed of the first machine.

TABLE III.

Machine	Length of sheet leaving. inches	Efficiency per cent.	Roll Speed Ratios.
1	23	42	1.00
2	26	38	$1.0 \times \frac{26}{23} \times \frac{42}{38} = 1.25$
3	$28\frac{1}{2}$	38	$1.25 \times \frac{28.5}{26} \times \frac{38}{38} = 1.37$
4	$31\frac{1}{2}$	28	$1.37 \times \frac{31.5}{28.5} \times \frac{38}{28} = 2.05$
5	$33\frac{1}{2}$	22	$2.05 \times \frac{33.5}{31.5} \times \frac{28}{22} = 2.78$
6	$33\frac{1}{2}$	60	$2.78 \times \frac{33.5}{33.5} \times \frac{22}{60} = 1.02$

These figures are given only as an example of the theory underlying the control of roll speeds and must not be regarded as typical of the ratios commonly met with in practice. The sheet produced in this experiment was only .08 inch thick and the effect of producing such a thin sheet becomes apparent in two directions (1) an exceptionally large increase in length, (2) exceptionally low efficiencies in the later machines. These two defects combine to necessitate a far larger increase in roll speeds than is met with in normal practice when a thicker sheet is being produced.

The above calculations are based on the assumption that the variation in peripheral speed is obtained by varying the number of revolutions per minute of rolls of constant diameter throughout the battery. An alternative method, that has been used with success in one of the best known of the proprietary batteries, is to vary the diameters and keep the revolutions per minute constant. Only the former method is available to estates who wish to make the fullest use of their existing rolls—usually six inches in diameter. Slight adjustments after erection are effected far more easily by slight alterations in the sizes of wooden pulleys than by alterations to the diameters of the rolls themselves.

The pulley sizes actually in use on estate "X" are shown in the diagram (Figure 5). The resulting ratios of roll speeds are as follows :

Machine	Ratio of roll speeds.
1	1.00
2	1.20
3	1.37
4	1.62
5 (Marker)	1.08

These ratios have been found to be quite satisfactory for producing sheet of about one-eighth of an inch in thickness.

Rather fuller information is available concerning estate "Y" and it is possible to give actual figures for roll speeds and sheet speeds. When the first observations were made the battery had been running for a week and it was obvious that some adjustments were necessary. The following figures were obtained by rolling one short length of coagulum through each machine separately.

TABLE IV.

Machine	Length of sheet issuing. Inches.	Time of passage. Seconds.	Speed of sheet In./Sec.	Speed of Rolls.			Efficiency per cent.
				R.P.M.	Ratio.	In./Sec.	
1	42	7.0	6.9	50	1.00	15.8	38
2	45	5.5	8.2	56	1.15	17.5	47
3	50	6.0	8.3	62	1.24	19.5	43
4	60	10.5	5.7	$62\frac{1}{2}$	1.25	19.7	29
5	63	9.5	6.6	64	1.28	20.1	33
6	64	6.0	10.6	$53\frac{1}{2}$	1.07	16.9	63

It has already been pointed out that for perfect harmonisation all the times in the third column should be equal. These times were actually very inconsistent and, as would be expected, the battery could not handle continuous coagulum without considerable tearing and piling-up in various places. The most outstanding example was the continuous tension and the resulting tearing between machines 5 and 6. This, of course, was due to the fact that, although the marker produced practically no increase in length, the natural speed of travel of sheet on this machine was over 50 per cent greater than the speed with which it left No. 5 machine. The table also discloses that machine No. 4 produces an exceptional increase in length, viz. 10 inches as against an average of 4.4 inches per machine. This means that the machine is overworked as exemplified by a very low efficiency and a low sheet speed. On the basis of these considerations it was therefore decided to reduce the speed of the marker in order to eliminate tearing between Nos. 5 and 6, (2) to open slightly the clear-

ance of No. 4 machine and to reduce that of No. 5. After these alterations were completed the following observations were recorded :

TABLE V.

Machine.	Length of sheet issuing. Inches.	Time of passage. Seconds.	Speed of sheet In/Sec.	Speed of Rolls.			Efficiency. per cent.
				R.P.M.	Ratio.	In/Sec.	
1	41	6	6.8	50	1.00	15.8	43
2	47½	6.5	7.3	56	1.12	17.5	41
3	53½	7	7.7	62	1.24	19.5	39
4	58	7.5	7.8	62½	1.25	19.7	39
5	58	6	9.6	64	1.28	20.1	45
6	58½	6	9.7	50	1.00	15.8	61

It will be seen that the "times of passage" were now very much more even, that No. 4 machine had been relieved of its excessive burden and that the cause of tearing between Nos. 5 and 6 had been eliminated. It is clear that by this method of treatment the figures could still be further improved but in practice this was found unnecessary. The battery was now capable of machining continuous coagulum from latex of 1¾ lbs. per gallon with very little tearing and with the production of sheet of just under one-eighth of an inch in thickness. It is obvious that, when continuous sheet is passing through the battery, a certain amount of self-adjustment takes place and that the actual speeds of the sheet on the various rolls are not exactly the same as those obtained from a small sheet which passes through each pair of rolls independently. This method of calculation is useful however in detecting and eliminating disharmonies which are too great to be overcome by the self-adjusting powers of the system.

A comparison of the ratios of the rolls speeds of the five-machine battery with those of the six-machine battery is of interest. On estate "X", with only five machines, the fastest machine has a speed of 1.62 times that of No. 1. On estate "Y", with six machines, the fastest speed is only 1.28 times that of No. 1. In the six-machine battery, each pair of rolls performs an easier task and the efficiency does not fall off very much from the first machine to the last. The higher speeds of Nos. 3 and 4 machines of the five-machine battery are necessitated by the larger decrease in efficiency which results from the greater burden imposed on the machines.

In conclusion it is essential to remember that however carefully the relative speeds of rolls of a continuous battery are adjusted, good results cannot be obtained unless a satisfactory coagulum is available.

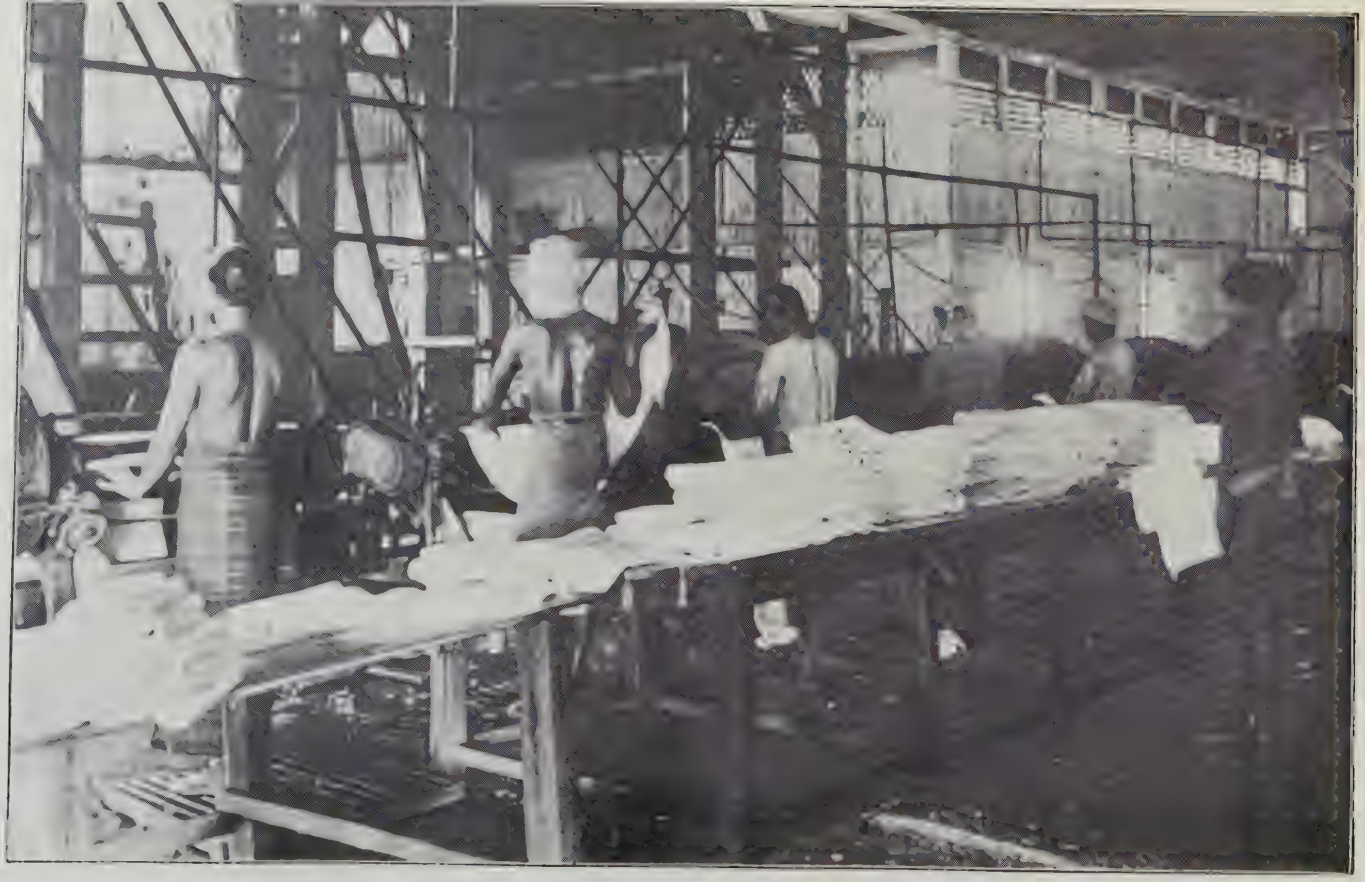


FIGURE 1

Estate "X"—Before conversion

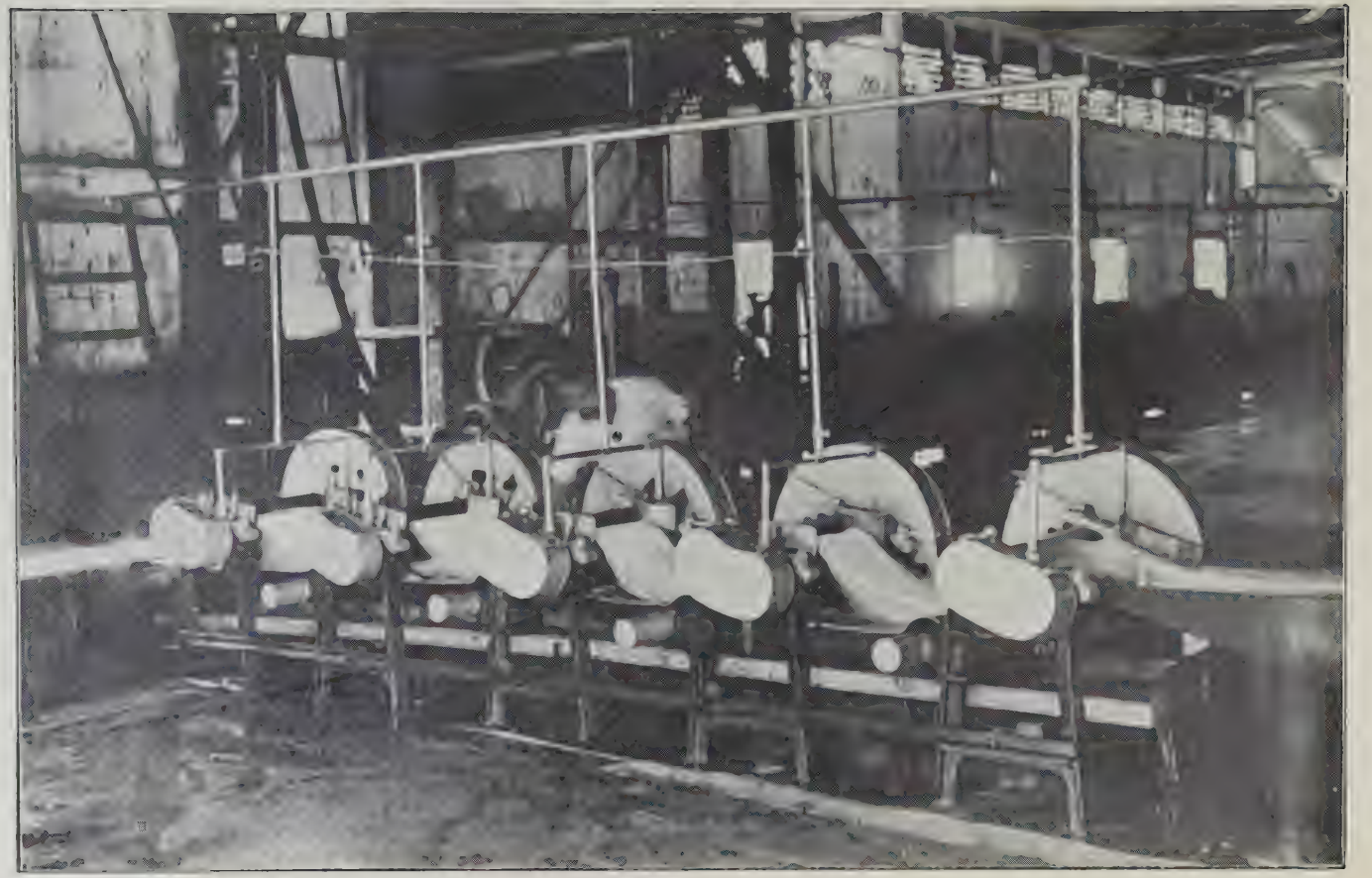


FIGURE 2

ARRANGEMENT OF PULLEYS ON ESTATE "X"

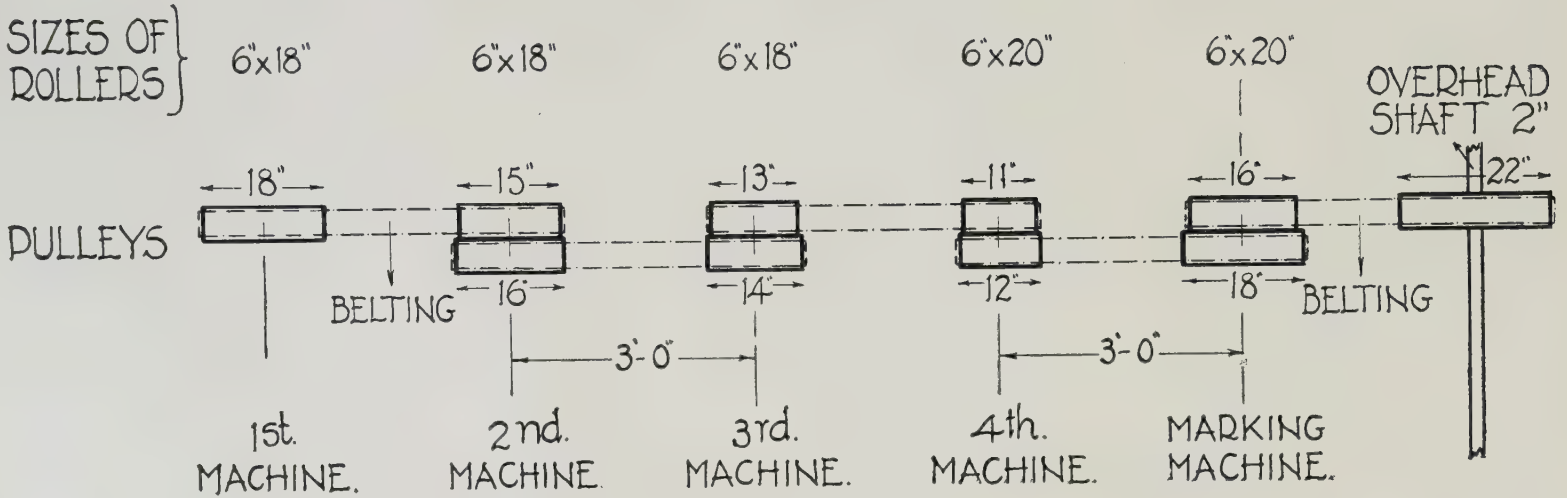


FIGURE 5.

The two controlling factors are uniformity and softness. Uniformity in coagulum permits of smooth running and the minimum of stoppages. Softness in coagulum leads to a thin sheet which can be thoroughly washed and which dries or smokes in a short period. Thus from the view-point of the management of an estate the nature of the coagulum is of prime importance.

From the wider aspect of the desire to give the consumer a satisfactory product the same considerations apply. It is shown on page 151 of this Journal that uniform coagulum fed to a uniformly acting battery suffers a fairly constant degree of spread. It is significant that the vulcanising properties of the resulting sheets are also uniform. It therefore follows that uniformity in the properties of any one day's crop is best obtained by bulking, coagulating under standard conditions and subjecting the uniform coagulum thus obtained to a uniform mechanical treatment. In this way the efficiency of the estate factory and the satisfaction of the consumer will both be increased to the maximum.

Kuala Lumpur, F.M.S., 31st October, 1932.

SULPHURIC ACID AS A LATEX COAGULANT.

BY

J. L. WILTSHIRE.

The replacement of formic or acetic acid by sulphuric acid for coagulating has the obvious attraction of saving money, but this acid undoubtedly has a bad reputation among planters and the published literature on the subject is not encouraging. Several authors of standard books on estate practice have emphasised the results of Martin (1) who observed that the addition of one-eighth of one per cent of sulphuric acid to dry rubber caused a very marked retarding effect on the rate of vulcanisation. As, however, the total amount of acid used for coagulation is approximately one-half of one per cent and by far the greatest proportion of this will be removed in the serum and in the wash-water it seems unlikely that any quantity approaching Martin's figure would be allowed to remain in the rubber. Martin's results can be regarded as nothing more than a warning and certainly do not constitute any real evidence of the unsuitability of sulphuric acid.

Eaton (2) studied the subject more exhaustively and found that rubber coagulated with sulphuric acid did, in general, show a lower rate of vulcanisation than acetic acid rubber. The greatest differences were found in slab rubber and the effect on sheet and crepe was very much smaller. In some of the figures reported for sheet there was practically no difference at all. Eaton lays particular stress on the fact that any such effects are greatly magnified by the use of an excess of acid over the minimum. This fact coupled with the very large retardation shown by slab is a strong indication that any effects of sulphuric are not caused by direct chemical action during coagulation but by the delayed action of that part of the acid which is retained by the rubber.

De Vries (3) also records the retarding effect of this acid but states quite definitely that "when the minimum quantity is used the difference between the rubber coagulated with it and with acetic acid is small and such small quantities can be used without objection". He also reports that the ageing properties of rubber coagulated with a minimum quantity of sulphuric acid are perfectly satisfactory. No special deterioration could be detected unless large quantities were used—such as one part of

acid to 22 parts of rubber. The normal proportion is approximately one part to 160 parts of rubber.

Morgan (4) in his standard text-book is distinctly conservative but states that sulphuric acid may be used IN THE VERY SMALLEST QUANTITY without harmful results. He recommends that it should only be used in the absence of the commoner and much safer coagulants.

The unpopularity of the acid among planters is probably due, to some extent, to the published statements noted above but undoubtedly its chief cause is a very lively—even exaggerated—realisation of its corrosive properties. This can be remedied by experience and several well-known estates have been using sulphuric acid for many years with almost complete freedom from accidents.

The information previously available may therefore be summarised thus:

(1) Sulphuric acid is perfectly satisfactory as regards the actual coagulation.

(2) It is harmful to the rubber if used in excessive quantities.

(3) It is particularly harmful under certain conditions which lead to the retention of a large proportion of the acid in the rubber.

(4) If used in minimum quantities and removed as completely as possible the harmful effects are negligible.

(5) It has been shown by experience that the corrosive properties do not constitute any bar to the efficient use of sulphuric acid, provided it is used with intelligent caution.

The published figures for the amount of acid required, together with the market quotation for formic and sulphuric acids, showed that the introduction of the latter would halve the cost of the coagulant i.e. by reducing it from .10 to .05 cent per pound. It was therefore decided to carry out certain confirmatory experiments with a view to collecting sufficient evidence to enable considered advice to be given on this subject.

Experiments on the quantity of Coagulant

A series of coagulations were carried out with varying quantities of sulphuric acid and the resulting coagula were machined at the appropriate time. The acid was introduced about noon and any coagulum not sufficiently firm for machining by 4.0 p.m. was allowed to remain until 8.0 a.m. the following morning. The time of machining is therefore described as "same day" or

"next day". The method of machining was the same throughout and each coagulum was passed through six machines with definite clearances. In every case one gallon of latex of D.R.C. 1½ was coagulated. The area of each dried sheet was determined by measurement and since each sheet is of the same weight and has had the same mechanical treatment this area may be regarded as a very fair indication of the "softness" of the coagulum at the time of machining.

For convenience in the laboratory all quantities of acid are expressed in terms of grams of pure acid of specific gravity 1.84. These figures may be converted to more practical units using the equivalent:—2.0 grams of pure acid per pound of dry rubber is equal to one fluid ounce of pure acid per 26 pounds of dry rubber.

The results of these experiments are shewn in the table.

TABLE I.

Sheet No.	Quantity of latex	D.R.C.	Quantity of acid gms. per lb.	When machined	Area of dry sheet
1	1 gallon	1½ lb gl.	1.33	next day	534sq. ins.
2	,,	,,	,,	,,	549
3	,,	,,	2.00	same day	579
4	,,	,,	,,	,,	570
5	,,	,,	,,	next day	405
6	,,	,,	,,	,,	375
7	,,	,,	2.66	same day	{ sheet spoilt
8	,,	,,	,,	,,	{ in machining
9	,,	,,	,,	next day	512
10	,,	,,	,,	,,	480

The coagulation in samples Nos. 1 and 2 was not very satisfactory—the serum being slightly cloudy and the coagulum rather uneven. With 2.0 grams per pound Nos. 3 and 4 machined on the same day without any difficulty, but with 2.66 grams per pound the coagulum was too soft for same day machining. This is a most important point, and in any factory experiments with sulphuric acid it must be remembered that reducing the quantity of acid may give a faster coagulation. It must also be emphasised that if the acid used is the quantity sufficient for same day machining and the coagulum is allowed to remain till next day, it will then be unnecessarily hard. This is shown by the area figures recorded for the various sheets. Thus samples 3 and 4 have spread to an area of approximately 570 sq. inches but the same coagulum left till next morning gives a sheet of approximate

area 390 sq. inches—a reduction of 32 per cent. This, of course, represents a corresponding increase in thickness and in time of drying. The experiments recorded below will furnish very potent reasons for maintaining the thickness of sulphuric acid sheet at a minimum.

In view of these remarks it will be seen that for normal practice of machining "next morning" the most suitable quantity of acid is about 2.7 grams of pure acid per pound of dry rubber. Figures have been obtained from certain estates for the quantity actually in use, which agree with these laboratory results. Thus one estate coagulating at 1¼ lb. per gallon used 3½ fluid ounces of acid per 50 gallons of latex i.e. 2.9 grams per pound. Another estate coagulating at 1 lb. per gallon uses 1 oz. of acid per 20 pounds i.e. 2.6 grams per pound of rubber.

Vulcanising Properties of Sulphuric-Coagulated Rubber.

The vulcanisation of the various samples have been carried out under the standard conditions previously described in this Journal by Bishop and Fullerton. All tensile properties are expressed as a modulus—the stress in kilograms per square mm. for an elongation of 650%. From each sample three mixes are cured and six rings are pulled corresponding to each time of cure. If more than three of these six rings fail to reach 650% elongation the sample is regarded as overcured.

The samples vulcanised correspond to Nos. 3 and 9 in Table 1. i.e. at 2.0 grams per pound machined same day and 2.7 grams per pound, machined next day. For comparison two acetic acid coagulated sheets were also treated—one from same-day machining and one from next-day machining.

TABLE II.

Sample No.	Acid	Grams per pound	Machined	Modulus kgs/sq. m.m. @ 650% elongation				
				Time of cure. minutes				
				80	100	120	130	140
3	sulphuric	2.0	same day	0.48	0.79	1.16	1.31	over-cured
9	sulphuric	2.7	next day	0.38	0.64	0.92	...	1.25
11	acetic	4.1	same day	0.46	0.72	1.05	1.21	over-cured
12	acetic	2.8	next day	0.67	1.15	1.39 (110)	over-cured	

These results are better expressed in graphical form and reference to Figure 1 will show immediately the small retarding effect of sulphuric acid.

VULCANISATION PROPERTIES OF AIR-DRIED SHEET.

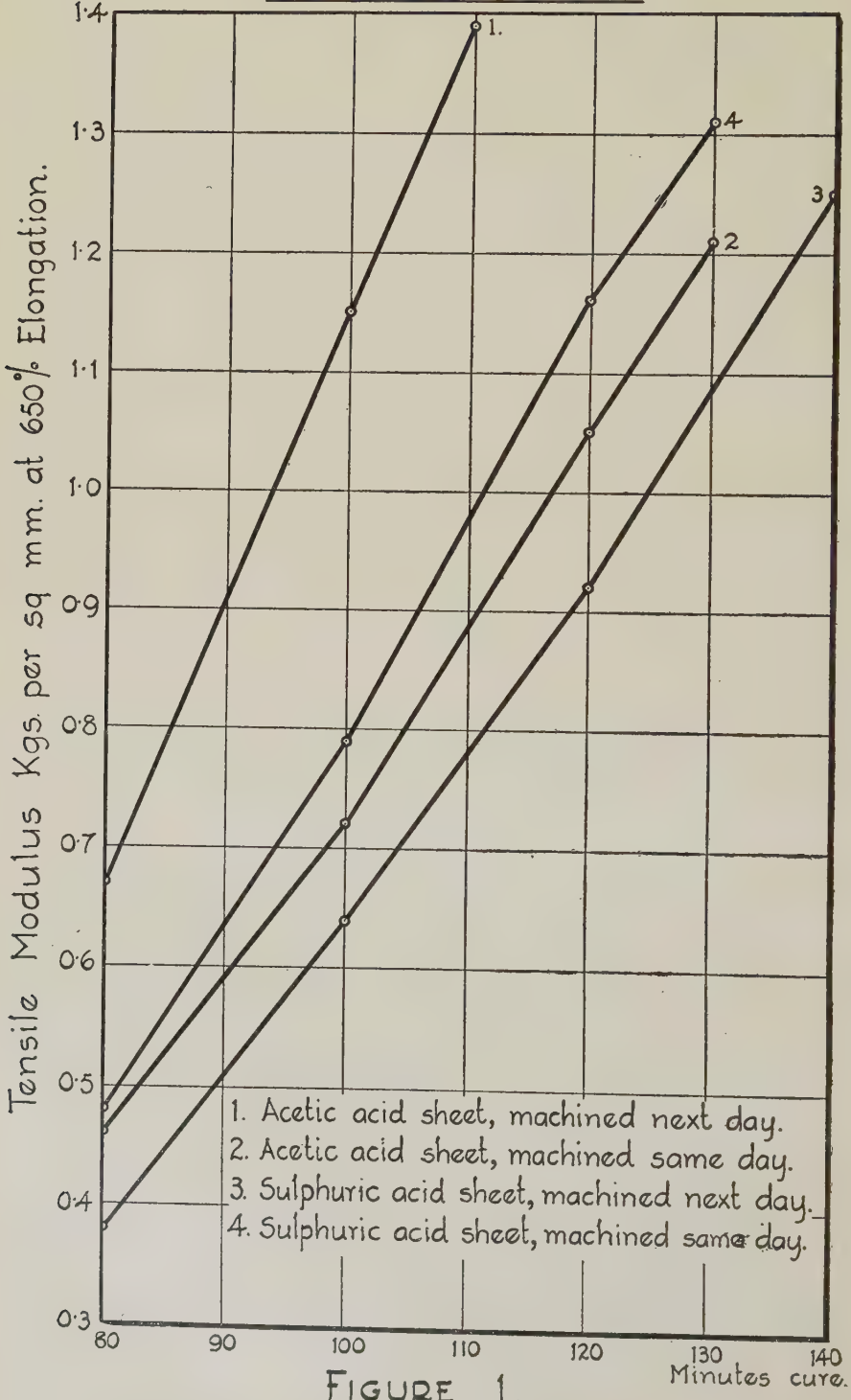


FIGURE 1.

In sheet coagulated with acetic acid the effect of same-day machining is to retard the rate of cure whereas with sulphuric acid the sheet machined on the same day is faster curing than that machined the following day. In both cases these differences may be attributed to the fact that coagulum machined only a few hours after the addition of the acid is machined thinner and is washed more efficiently than the tougher coagulum obtained by overnight coagulation. The controlling factor in acetic acid sheet is the amount of serum constituent remaining and the actual acid—being volatile—is of little importance. Hence a well washed rubber is slower curing, as shewn by the difference between sheet and crepe. In sulphuric acid sheet the retarding effect of the acid is of greater importance than the accelerating effect of the serum constituents. Hence the well-washed sheet is faster curing. All these sheets have been air-dried and it is the general rule that air-dried are somewhat slower-curing than smoked sheets.

The retarding influence is, however, not very great and extreme difference between the times for reaching the maximum modulus is only 30 minutes i.e. between 110 and 140 minutes. The maximum moduli attained by the sulphuric acid sheets are also of the same order as those given by the acetic acid sheets. The experiments support the statements made above that the use of sulphuric acid in minimum quantities, accompanied by thorough washing during machining, is not harmful to the resultant rubber.

The position with regard to use of sulphuric acid may now be summarised thus:—

(1) Sulphuric acid gives satisfactory coagulation at a cost approximately one-half of that of formic acid and one-third of that of acetic acid.

(2) It is not harmful to the rubber provided that

  (a) it is used in the smallest possible quantity

  (b) the sheet or crepe is washed with abundant water during machining

(3) By the exercise of caution in the handling of the acid, the personal damages attendant on its use can be practically eliminated.

These conclusions may be somewhat amplified:—

(1) The cost of sulphuric acid varies with the method of packing and with the quality. It will not be sufficient for a manager to ask his agents or his dealers merely for sulphuric acid without qualification. The acid purchased should be a good quality

commercial grade, of specific gravity 1.84 (sometimes sold as 168° Twaddell). It will usually be found cheapest to purchase the acid in 2½ cwt drums and not in glass bottles. The use of inferior grades of acid may cause trouble and we recommend the use of only well-known British grades.

If the acid is of the above-mentioned gravity the figures given in this paper may be applied without further correction for purity. Estates purchasing more dilute acids are advised to submit samples to the R.R.I. for analysis.

(2) Estates commencing the use of sulphuric acid must be prepared to spend a week or two on experiments designed to determine the most satisfactory quantity of coagulant to use. For next-day machining, using a latex of 1½ lbs D.R.C. the figures mentioned previously may be taken as a starting-off point i.e. 2.66 grams per pound of dry rubber or approximately 1 fluid ounce of acid per 20 pounds of dry rubber. The use of the smaller quantity shown in Table 1 i.e. 2.0 grams per pound or one fluid ounce to 26 pounds of dry rubber may be found satisfactory for same-day machining but this coagulum will be unduly tough and difficult to wash if left overnight.

(3) Safe handling of sulphuric acid is mainly a matter of common sense but certain cardinal points may be mentioned:—

(a) when diluting, the acid should always be added to water and not water to acid.

(b) the addition should always be made slowly.

(c) sulphuric acid should never be held above level of the eyes or poured in such a position that splashes could reach the eyes.

(d) when moving sulphuric glass bottles containing sulphuric acid they should be held at the bottom and never at the top.

The acid must be added to the latex in very dilute solution and the most convenient mixture is 50 fluid ounces of pure acid per 50 gallons of water. The number of fluid ounces of acid being added to any quantity of latex is then easily checked.

It is sometimes suggested that the safest method is for the manager to dilute the pure acid immediately it is received at the factory. This method insures against unauthorised tampering with the acid in its most dangerous form. The acid may be only

partially diluted at this stage—say to 30%—and then further diluted immediately before use. In a well-disciplined factory this preliminary dilution may be regarded as rather unnecessary.

If used in the minimum proportions, the sulphuric acid contained in the serum will not cause any great corrosion of the machines. It is essential however, that after machining is completed, fresh water should be run over the rolls for some minutes to ensure that the film of water which remains is quite free from acid. If this precaution is not observed the evaporation which takes place during the day may leave on the rolls a very small quantity of a very concentrated acid and the cumulative effect of this daily treatment may cause appreciable corrosion.

In conclusion it should be emphasised that in the use of sulphuric acid, considerations of cost, efficiency and quality of products all point in the same direction. The lowest cost is obtained by using a minimum quantity of acid; this yields the softest coagulum; this in its turn facilitates washing and yields the thinnest and fastest drying sheet; the efficient washing is responsible for producing the fastest curing and least acid rubber.

Since writing the above certain facts have come to our notice which must be given due prominence in any discussion of the subject.

Several estates have recently experimented with sulphuric acid and some have obtained satisfactory results almost immediately. Others, however, have experienced considerable difficulty in obtaining a satisfactory and consistent coagulation. The chief difficulty appears to have been bubble formation—at least partially caused by insufficient accuracy in the measurement of the acid and careless or unduly prolonged stirring. In most instances it has been found possible to overcome these difficulties, but it must be admitted that this coagulation is less easily controlled than the normal formic acid method. We again stress the fact that the manager turning over to sulphuric acid must expect to devote a certain amount of time to preliminary trials and errors.

The other outstanding fact is that some brokers and consumers still maintain their opposition. There is, of course, no uniformity of opinion on this point and, that sulphuric acid sheet is acceptable to some consumers, is shown by the fact that several estates have been selling such sheet at top price for many years.

The question may be settled for any particular seller by submitting preliminary samples of sulphuric acid sheet, prepared on a small scale, in the normal market. It is desirable, however, to quote in full the warning printed in the R.G.A. Bulletin of August 1926 which, since it has not been revoked, presumably still represents the official opinion of the R.G.A.

"A communication has been received recently from the "Rubber Association of America intimating that at a meeting "of the Board of Directors of that Association the matter of "the use of sulphuric acid as a coagulant was considered. "The question arose on account of the apprehensions expressed "by a representative group of technical men with respect to "probable harmful effect of sulphuric acid on the curing and "ageing qualities of rubber. The Directors of the Association "share the apprehension of their technical men and asked the "assistance of the R.G.A. in endeavouring to discourage and "possibly eliminate sulphuric acid as a coagulating agent.

"It will be remembered that a warning against the use of "sulphuric acid as a coagulant was published in the Bulletin "for May 1923 pp. 247/9 and it was then stated that the dis- "advantages attaching to this substance had been reported "from time to time. It has been clearly shown that coagula- "tion with sulphuric acid produces a rubber which cures more "slowly than that prepared with acetic acid. Further, if more "sulphuric acid is used than is necessary, the effect on the rate "of cure of the rubber produced is much greater than it would "be if a similar excess of acetic acid were employed. On most "estates it is usual to employ a slight excess of acid over the "minimum amount so as to ensure a clean coagulation under "all weather conditions, and consequently if sulphuric acid be "used the slightest excess of acid necessary will be harmful. "It may be of interest to recall the fact that sulphuric acid was "only suggested as a makeshift during the war when supplies "of acetic acid were not available. Sulphuric acid is a cheaper "acid than acetic and goes further but the saving in cost does "not warrant its use. It is possible that the use of sulphuric "acid accounts for complaints from manufacturers as to the "variability in the rate of cure of plantation rubber which "continue to be received.

"Estate managers are strongly recommended to return to "the use of acetic acid, or to utilise sodium silicofluoride or "formic acid as recommended in the Bulletin for September "1925. Sulphuric acid is not recommended for coagulating "latex."

This advice was given in 1926 and was probably very sound advice. It has been quoted to us in correspondence in 1932 when its soundness is more problematical. Conditions have changed very considerably in the intervening period and several pertinent remarks may be made. In August 1926 the price of rubber was one shilling and sixpence per pound and the approximate costs of coagulating with acetic and sulphuric acids were 0.17 and 0.05

cents per pound respectively. In 1932 the price of rubber is approximately two pence per pound and the acid costs are not very different from those of 1926. The saving represented by sulphuric acid is now a very much larger percentage both of the cost of production and of the margin between production cost and selling price. Again, methods of factory control have greatly improved and there now appears to be very little necessity for using more than the minimum quantity of acid, whatever coagulant is used. As regards the variability of plantation rubber there is much evidence to show that this is still considerable even amongst estates using only formic acid. The intelligent use of sulphuric would not increase this variability very greatly and, as far as each individual estate is concerned, the absolute necessity for the strictest control of the amount of acid used would probably lead to a more uniform product.

It is impossible for us definitely to recommend the use of sulphuric acid since the varying requirements in different markets renders the problem as much commercial as technical. It is possible to produce a good quality rubber by the use of sulphuric acid, provided sufficient care is exercised, but even the best rubber thus produced may prove unwelcome if it falls into the hands of a buyer who has a fundamental and long-standing objection to the coagulant.

References.

1. Martin, W. G. *Rubber Industry* (1914) p. 205.
2. Eaton, B. J. *Agri. Bul. F.M.S.* No. 27 (1718) p. 223.
3. De Vries, O. *Estate Rubber* (1920) p. 176.
4. Morgan S. & Stevens H.P. *Preparation of Planation Rubber* (1928) p. 303.

Kuala Lumpur, F.M.S., 31st October, 1932.

EFFECT OF METEOROLOGICAL FACTORS ON THE VIRULENCE OF OIDIUM HEVEAE IN MALAYA.

BY

F. Beeley.

Introduction.

It has now been known for some considerable time that although the rubber trees of Malaya have carried a heavy infection of the fungus causing Abnormal Leaf Fall no real epidemic of leaf-fall has yet occurred. Some districts certainly have suffered to a moderate extent, but not sufficiently to merit the adoption of the necessary control measures, nor to cause any apparent reduction in yield or vigour of the trees. On the other hand observers in the hill country districts of Java and Sumatra and the high level districts, Matale and Uva, in Ceylon report that many trees may become completely defoliated several times during the dry season when wintering takes place. It is obvious therefore that there is some natural factor which governs the activity and virulence of the fungus in Malaya. It should here be pointed out that the rubber trees in the low lying districts of Ceylon, Java and Sumatra are also only slightly affected by the fungus, and that the amount of leaf-fall in such districts is only slight although the fungus is present. The rubber trees are seriously affected by mildew only in those rubber districts at an altitude of over 1000 ft. It is unfortunate, for scientific reasons, that Malaya has no rubber growing at altitudes of above the 400 foot level. Altitude has two main effects viz:

(1) Reduction of air pressure.

(2) Reduction of temperature.

Reduction of barometric pressure is small, being only about one inch per one thousand feet, and can have little effect in itself on the growth of fungi and plants. The effect of altitude on temperature however is quite appreciable, being a reduction of approximately 3°F on the night and 5°F on the day temperatures per 1000 feet rise above sea level. Reduction of temperature therefore, may have a very great effect, more especially upon such delicate and specialised fungi as the mildew fungi.

It seems therefore that a study of the meteorological factors of Malaya and a comparison with those of Ceylon is most likely

to throw light on the Abnormal Leaf Fall problem. It is this aspect of environmental conditions which forms the basis of the following discussion.

Laboratory Experiments.

These were carried out to determine conditions for growth of the fungus *Odium Heveae*. This fungus belongs to the group of fungi known as true parasites. It has not yet been grown on dead material or on artificial media normally used for the culture in the laboratory of fungi and bacteria. It is therefore very difficult to make laboratory observations under controlled conditions, and particularly with plant tissues like those of the rubber tree, where latex exudation tends to stop up the cut ends of branches brought into the laboratory, making it almost impossible to keep such a small branch alive in a culture chamber for more than a few days. However, the results so far obtained tend to show that certain conditions, within comparatively narrow limits, may be necessary for the growth and propagation of the fungus.

For several months following the normal wintering season in the years 1930, 1931, & 1932 infected branches have been brought into the laboratory, their cut ends immersed in flasks containing tap water and kept in a cool chamber in which the humidity was fairly constant. The variation of temperature within the chamber was noted and the humidity values calculated from the wet and dry bulb thermometer readings.

By this means the following results concerning the optimum conditions for growth of the fungus were repeatedly observed during the three wintering seasons and at all times of the years during which the observations were carried out.

1. In a cold chamber at a temperature varying between 56°F and 62°F, excellent growth of the fungus occurs producing rapid spread over leaf and flowers and production of chains of 3—7 spores many of which germinated in situ as there was no wind in the chamber to carry the ripe spores away. Growth continued for seven days when the rubber leaves wilted and the fungus dried out.

The percentage Humidity within the chamber was calculated to vary between 75 and 80.6 per cent.

2. At laboratory room temperature 72°F—92°F medium growth with production of short chains of 2—3 spores took place. It was observed that very few of the spores seemed to germinate either in situ or after having fallen on to the plant surfaces. This slow growth continued for three to four days

when wilting and drying out occurred. The percentage Humidity was calculated to vary between 50 and 93 per cent.

3. In a cold chamber at temperatures varying between 45°F and 50°F a good spread of mycelium over the leaf surfaces was first obtained, but very few conidiophores were produced; each conidiophore had one immature and more rarely a ripe spore attached. The fungus wilts and disappears from the leaf surface after four days though the rubber leaves and flowers are still in good condition and remain so for six days before the flowers drop and the leaves definitely wilt.

Several flasks containing infected rubber leaves revived to produce numerous conidiophores and conidia when placed in the warmer chamber (56°F—62°F) after two days' inactivity in the colder chamber.

The percentage Humidity of the colder chamber was calculated to vary between 73.6 and 78 per cent. This chamber was the lower section of the chamber referred to in experiment No. 1 above.

It was noted that in all the three experiments mentioned above, the youngest leaves ($\frac{1}{2}$—2″ long) on the branches tested, wilted within 2 to 3 days and the fungus did not develop on them. The longer half grown semi-rigid leaves remained alive longest and carried the heavier growth of fungus.

Water relationship within the leaf, i.e. cell turgidity would therefore seem to affect the rate of growth, spread and infection powers of the spores.

Experiments on growth in culture media also showed that a considerable increase both in amount and rate of germination took place in the cold chamber as compared with that of spores kept at atmospheric temperatures. At the latter temperature the development of extraneous fungi so masked the plates after two days that no ultimate figure for germination could be determined. It is of little importance, however, for the wilting of spores during the dry midday temperatures may be observed under the microscope to take place within three hours even when the spores are still attached to the parent mycelium on small portions of the floret or leaf. An indication of the difference in rate of growth and percentage germination of spores of *Oidium Heveae* in low and high temperatures may be obtained from the following figures recently obtained.

Material for inoculation was obtained by incubating Heavea inflorescences for two days in the cold chamber. A small piece of the inflorescence heavily laden with the fungus in a vigorous sporulating state, was shaken over the surface of nutrient agar

which had previously been aged for two weeks in petri dishes in the cold chamber. These plates were then incubated at the different temperatures. Plates incubated at air temperatures varying from 72 F at night to 90°F at noon and percentage humidity of 95 to 45 gave 6.9 per cent germination of spores in 24 hours and no further germination after that period when the contents of the spores collapsed. The length of germ tube produced during this period varied in length from 6 μ to 20 μ.

Plates incubated in the cold chamber at temperatures varying between 56°F and 62°F and percentage humidity of 75 to 80 gave 60.3 per cent. germination in 24 hours, while most of the remaining spores maintained their original refractive appearance. The length of germ tube produced was mostly between 110 μ and 150 μ while others were much shorter, probably having germinated later.

The plates in the cold chamber remained clean for several days and after 48 hours, 78 per cent germination was recorded. On the third day the spores and germ tubes began to wilt, the substrate being unsuitable for vegetative growth of the fungus. It would seem therefore, that under Malayan conditions an Oidium spore when freed must quickly alight upon a suitable host substrate, germinate and become attached to its host in as short a time as possible if it is to survive and multiply to produce a disease of an epidemic nature. Extreme conditions, high or low temperature, dry or wet atmosphere cannot be favourable to an epidemic spread of the disease.

From the above details of laboratory cultures on living Heveae leaves we find that for optimum growth of the fungus and optimum production and germination of spores the following conditions are necessary :—

1. A temperature not lower than 56°F and not higher than 62°F.
2. A percentage humidity of 75—80 per cent.
3. Suitable living tissues on which to grow. Observation showed that fresh young rubber leaves of 2—3 inches long, the turgidity of whose cells are such as to afford the most easy ingress of the feeding organs of the surface mycelium of the fungus are most suitable.

With the help of Meteorological records supplied by the Meteorological Officers of Malaya and Ceylon it is possible to investigate the influence which various meteorological factors have upon the growth and spread of the mildew disease of rubber trees in Ceylon and Malaya.

It has been generally understood that the amount of rainfall has some considerable influence on the incidence and spread of

this disease, but reference to the rainfall figures of the various meteorological stations in the rubber growing districts of the western territories of Malaya and of the Matale and Uva districts of Ceylon, shows that the differences in rainfall totals are not so great as would cause such a vast difference in amount of disease and leaf-fall. The manner of its falling may however have some influence in that frequent light showers have no appreciable effect on the spread of the fungus while infrequent heavy rains definitely retard the rate of growth and spread of the fungus.

Such heavy rains may influence the disease in several ways.

1. By causing the fall to the ground of any ripe spores which may have developed during the interval between storms.

2. By stimulating a far more rapid growth of the buds and young leaves of the trees, so that the leaves rapidly assume a condition of turgidity and maturity unfavourable to the penetration of the fungus.

3. Reducing the range of temperature changes, a more moderate day temperature being experienced during such weather, while in dry weather the temperature ranges are greater, and high day temperature with low night temperatures are the rule.

4. Reducing the Humidity range for a few hours following the storm. Showery weather, however, will maintain this condition over longer periods, and hence humidity more favourable to the fungus obtains.

Rainfall thus has two definite effects (a) directly on the conditions favouring the growth of the fungus and (b) on the growth of the host tissues. From field observations it is the latter which is of the greatest importance in Malaya in that the induced rapid refoliation reduces the period of time over which the leaves are susceptible to attack.

Dr. S'Jacob (1) suggests the possibility that the growth of the leaf itself thickens the cuticle and prevents any further attack from the parasite.

Unfortunately sufficiently detailed figures from badly infected estates in Ceylon are not available but from the stations at Kandy and Badulla figures are available which give a good indication of the conditions obtaining in those districts of Ceylon which suffer most from mildew viz. the uplands of Matale and Uva respectively.

Before going on to discuss the climatic conditions of the different countries it would perhaps be best to describe the incidence and effects of the disease in the districts of both Ceylon (2) and Malaya.

In the lower rubber lands of Ceylon the fungus is active during the months of February, March, and April when wintering is taking place causing a mild fall of leaf.

In the uplands of Ceylon (2, 3) where rubber is grown, normal wintering takes place in February, March, and April. During these months as much as 30 per cent of the trees may have been defoliated, and the disease continues in certain parts for several months more producing further repeated defoliations until September, but even after this month the fungus is in evidence. A second wintering is commonly experienced in these districts in August due to dry weather conditions.

In Malaya it has been recorded that the rubber lands of Malacca have suffered more than those of any other Malayan state. This again may be due to the fact that generally the trees in that district are poorer, being grown on exhausted soils and thus cannot renew their leaves as quickly as those of other districts. A similar statement has been put forward regarding the upland rubber districts of Ceylon, that tea had been grown for many years previously or had been interplanted with the rubber. It has been the writer's experience that rubber trees on virgin soil well preserved from soil wash recover their new leaves more rapidly than those on heavily cropped lands where the rubber is poor and top soil has been lost so that the trees cannot take advantage of rain-water which rapidly drains away from the surface, there being no top soil to retain water.

From the tables I & II it will be seen that a dry period of low rainfall exists in the districts of Malacca and Badulla during January, February and March; while in Kuala Lumpur and Kandy the drought is not so marked. Badulla & Kandy maintain these drought conditions for several months more until the end of the Monsoon period in September, and during these months (2) the fungus is most active.

The rainfall for Kandy of 10.39 inches in March 1930 was rather abnormal. In March 1929 only 4 inches of rain were recorded, and this was also a bad leaf fall year.

Fig. 2., giving the number of days' rain per month indicates the manner in which the rain falls. At Badulla nineteen wet days in April, 1930, yielded only 4.25 inches of rain, an average of 0.22 inches per wet day. At Kuala Lumpur twenty wet days yielded 10.01 inches of rain, average of 0.5 inches per wet day. The heavy rains in the Kuala Lumpur district probably prevented an epidemic spread of the fungus, and induced rapid growth of the young leaves to maturity, thus reducing the period of time during which the leaves are subject to infection. The light rains in Badulla (Uva district of Ceylon) produced a slow growth of young leaves and by preventing high midday temperatures favoured the growth of the mildew fungus.

TABLE I.

Rainfall 1930 in inches.

Place.	Jan.	Feb.	Mar.	April.	Year.
Kuala Lumpur.	8.14	3.57	6.51	10.01	82.8
Malacca.	1.23	3.28	9.72	9.84	84.97
Badulla (Uva).	6.76	3.19	4.38	4.23	69.84
Kandy (Matale).	11.87	2.34	10.39	5.1	97.13

TABLE II.

Number of days' rain.

Place.	Jan.	Feb.	March.	April.	May.
Kuala Lumpur.	17	9	14	20	8
Malacca	10	4	15	15	13
Badulla (Uva).	17	6	11	19	9
Kandy (Matale).	14	5	10	13	17

The increase in the monthly rainfall for Malaya in April indicates generally a rapid renewal and growth of leaf, so that the mildew fungus has little time for development during this month. Reference to previous years' figures also supports the fact that heavy rains in April tend to prevent further serious activity and spread of the disease, though the active fungus can always be found on some of the more immature leaves and flowers during this period. It may be said that the growth of the leaves during wet weather far exceeds even the normal rate of growth and spread of the mildew fungus.

In plate I. is given a diagram representing the monthly rainfall for Kuala Lumpur during the years 1927 to 1932 and is to be compared with the corresponding diagram representing the incidence of Oidium, as determined by observation and number of confirmed reports of infected estates in Malaya. The sudden recovery after the April rains is easily noted.

The fact that the rainfall has a far greater effect on the rate of growth of the rubber leaves is of greater importance than the actual influence of rainfall on the mildew fungus itself. Other factors affecting the retention of moisture in the soil will naturally also have some influence in this direction.

Other meteorological factors such as hours of sunshine per day, amount of cloud and direction and strength of wind have been carefully considered and found to give very little help in the solution of the mildew problem, though doubtless slight wind is necessary to carry the spores from leaf to leaf and tree-to-tree, but this is always available for a short period at some time of the day in nearly all the tropical climates investigated.

It is of interest to note that Malacca has considerably more windy days per month than Kuala Lumpur, and this fact may be responsible for the increase in the mildew disease in that district as compared with other districts of Malaya.

The fungus prefers the underside of the leaf and is therefore always shaded from the midday sun. An analysis of the daily hours of sunshine and of amount of cloud for Selangor, and Malacca gave no indication of possible influences on the incidence of leaf-mildew.

Humidity and Temperature.

These two meteorological factors are taken together because in small tropical countries surrounded by sea the actual vapour pressure in the atmosphere is almost constant day and night in all seasons of the year. The actual percentage humidity varies according to the temperature and the barometric pressure. In Malaya the barometer readings vary not more than 0.4 inches and this is considered to be too small to have any effect.

Percentage Humidity is defined as the actual vapour pressure represented as a percentage of the maximum vapour pressure possible within the atmosphere at a given temperature.

Malaya normally experiences a very dry midday period and a damp night period, although the water vapour pressure in the atmosphere remains more or less constant e.g. at 27—29 mb. in the rubber growing districts of Selangor. This is due to the tremendous difference between day and night temperatures viz. 91°F to 70°F. It has been shown by laboratory tests that the fungus *Oidium Heveae* is subject to rather definite limits of both temperature and humidity for its optimum growth and germination of spores.

The graphs in plate II show, that in the Malay States the temperature is at all times above what is considered the maximum limit for optimum growth of the fungus. This assumes even more importance when considered in conjunction with the figure showing the hourly changes in humidity for the respective states, which indicate that for only about one hour in the morning 9—10 a.m. and for less than two hours in the afternoon 4—6 p.m. is the humidity value suitable for optimum activity of the fungus.

Alor Star (Kedah) has the lowest rainfall of all Malayan recording stations in the months of January and February, being only 0.5 in. per month and according to preconceived ideas should be far more subject to this type of Leaf Fall than any other district of Malaya. Often the rubber trees are without leaves for several weeks during this intensely dry period yet no reports of Abnormal Leaf Fall are forthcoming. Reference to the humidity and temperature records offer the most reasonable explanation. Both these factors have a big variation in the 24 hour period with the result that temperature is always unsuited and humidity favourable to the growth of the fungus, for only one hour morning and evening viz. 8—9 a.m. and about 7—8 p.m. the actual period varying slightly according to the period of the day during which rain falls.

The report of the papers read at the conference of Empire Meteorologists in 1929 (4) contains valuable information regarding the influence of climatic factors on the virulence of parasitic fungi and insects. Many instances are given where such vigorous parasites as Bunt in Wheat, the rusts of various cultivated crops, mildew of grain and vine and many others have been rendered inactive by temporary abnormal climatic conditions. It is indicated that definite conditions of moisture and temperature are necessary to the growth and power of infection of many parasitic organisms.

It would appear from both laboratory experiments and actual field observations in Malaya that *Oidium Heveae* behaves in a similar manner. Firstly temperature and secondly atmospheric humidity are factors which are chiefly responsible for the absence of any serious epidemic of this disease in Malaya. Further after a dry period in the early part of the year the advent of rain causes a rapid refoliation of the rubber trees thereby enabling the leaves to outpace the spread of the disease. These three factors go far to ensure that the rubber trees of Malaya remain comparatively free from abnormal leaf-fall.

The question may reasonably be asked why has this disease become so prominent in rubber growing countries during the past three or four years? Considerable difficulty is met with in answering and explaining this question. It might here be pointed out that several planters in the Malacca district who have had long experience of rubber in this country recall that in 1911—13 a similar mysterious leaf fall occurred but that it disappeared in later years. Unfortunately the writer has failed to find any authentic records of a disease of the young leaves in these years, but from the descriptions given and the fact that the planters

themselves felt sure of the similarity, it is probable that this disease was also caused by the same fungus.

Further the meteorologists tell us that annual weather changes show an approximate cycle of either 17 years, or more closely, a cycle of 35 years. It is therefore possible that the slight climatic differences from normal of the years 1928-32 correspond to those obtaining in 1911—13. The disease would not be so obvious in those early years the trees being then much younger and the soils comparatively more fertile, thus ensuring a quicker development of the young leaves.

Alternatively it must be considered that as there are many species of the Oidium fungi existing on other host plants in this part of the tropics it is possible that following the clearing up of such vast areas of jungle a type of fungus parasitic to rubber has been developed along natural lines. If this is so we must be prepared for more trouble from this disease in future years. It is, however, comforting to know that climatic conditions, particularly those of temperature and humidity are not suited to the optimum activity of fungi of this type. Consequently the rubber trees of Malaya may have practical freedom from the abnormal leaf fall caused by the fungus *Oidium Heveae*, unless, perchance, the commercial value of rubber should soon rise to such heights as would make it profitable to plant rubber on the precipitous slopes of Malayan mountains. Here, the temperature might be low enough to retard the refoliation of the trees following wintering, and favour the germination, growth and parasitism of the fungus to such an extent as to cause an epidemic of abnormal leaf fall. If leaf fall happens to occur in such areas and the yield is seriously lowered then sulphur dusting by means of power dusters will have to be resorted to as is the case in the uplands of Java, Sumatra and Ceylon.

Summary.

The meteorological conditions obtaining in the eastern rubber growing districts are described and compared.

The optimum conditions for growth and germination of spores of the fungus *Oidium Heveae* as determined in the laboratory are given, and taken as a basis upon which the influence of meteorological factors may affect the virulence of the fungus on rubber trees.

It has been shown that these optimum conditions are that suitable young plant tissues are available, that rainfall is not too heavy, that the humidity of the atmosphere is in the neighbourhood of 75 per cent to 80 per cent and that the atmospheric temperature is about 60°F.

It is then shewn that the climates of the high level rubber growing districts of Ceylon, Java and Sumatra more nearly approach these optimum conditions than does that of Malaya, where rubber is grown only at low altitudes and remains comparatively free from the disease.

References.

1. S' Jacob Dr. J. C. "Microscopical investigations on Heveae Mildew." *Archief voor de Rubberculture.* April 1930.
2. Murray, R. K. S. "The Control of Oidium Leaf-Disease" *Rubber Research Scheme Ceylon, Quarterly* Vol. **7**, part. 4.
3. Murray, R. K. S. "Diseases of Rubber in Ceylon" 1930" *Rubber Research Scheme Ceylon, Quarterly,* Vol. **8**, part 1.
4. Conference of Empire Meteorologists 1929,*Agricultural Section.* **II**.

Description of Plates.

Plate 1. The upper diagram shows the monthly rainfall in inches at Kuala Lumpur for the years 1927 to 1932 while below is a diagrammatic representation of the incidence of the mildew disease in Malaya. Note the reduction in disease following the March or April rains. Note also the peak year for the disease, 1931, when only moderate rainfall occurred during the early months of the year.

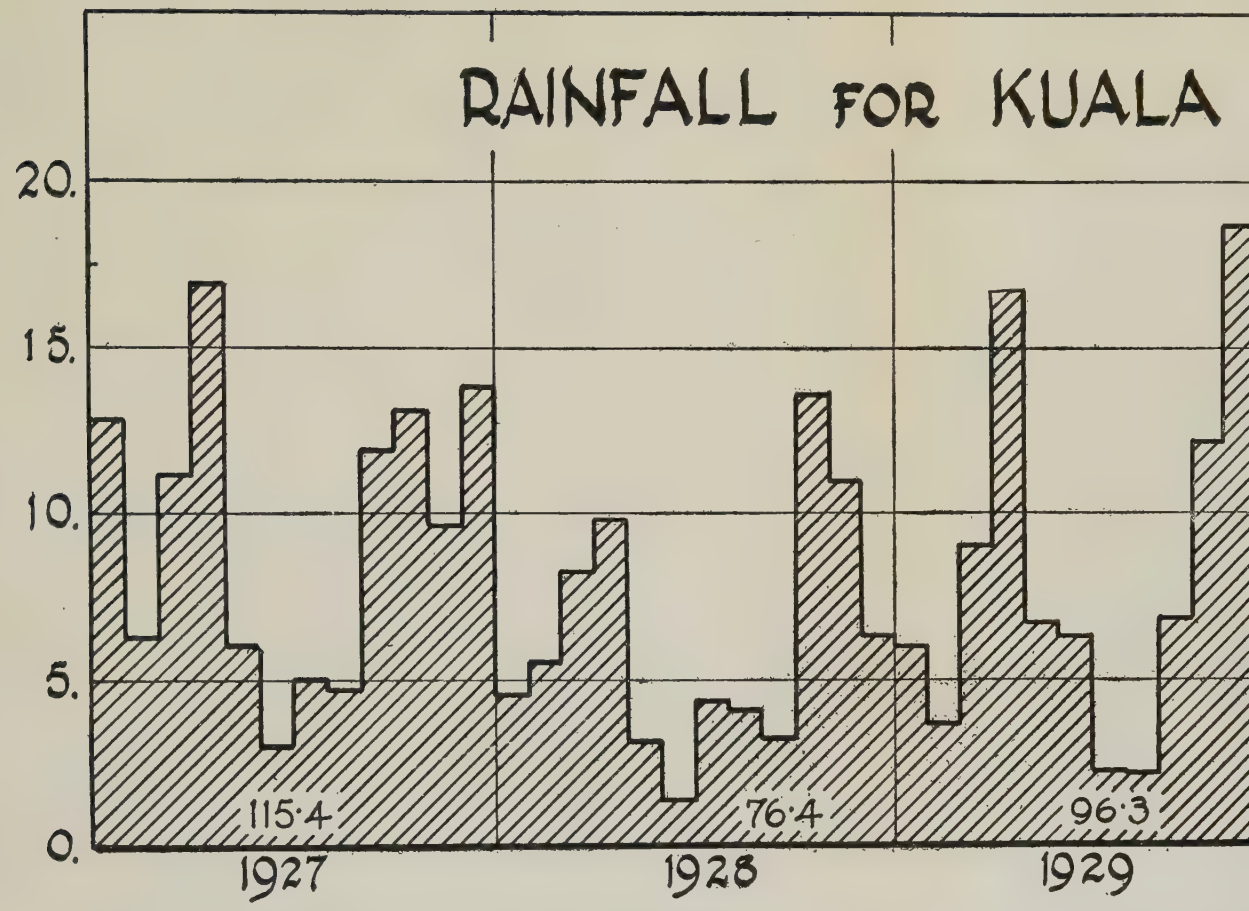
Plate 2. The upper graph represents the hourly changes in Percentage Humidity for a March day in Kuala Lumpur, Malacca and at Badulla in Ceylon. Note the close similarity between Ceylon and Malacca conditions, and their approach to the optimum range, while Kuala Lumpur enjoys an extremely dry period during the middle of the day.

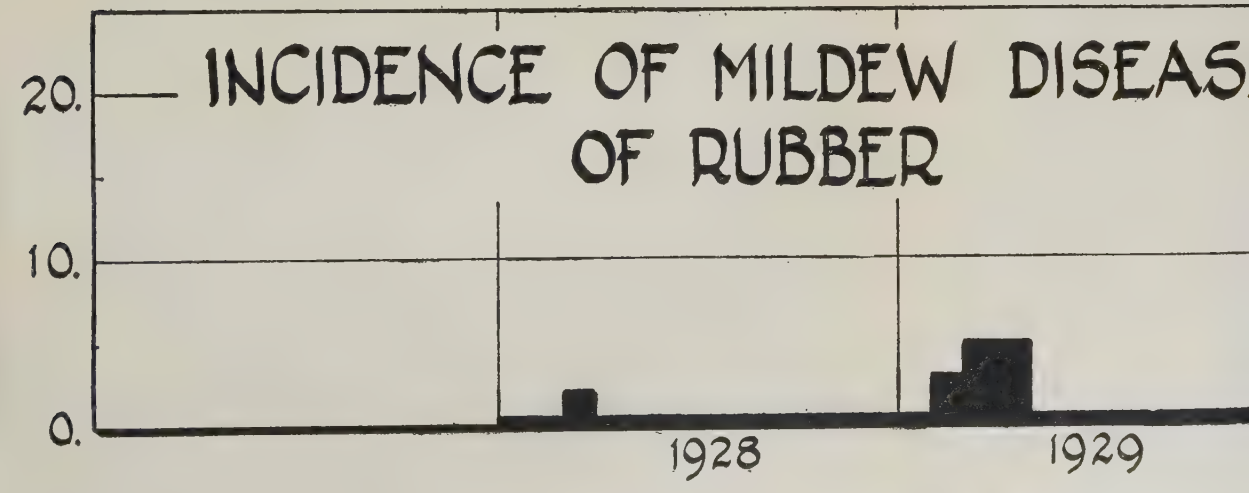
The lower graph gives the hourly changes in temperature for the same stations. Note that both Malacca and Kuala Lumpur are well above the optimum range for growth of the mildew fungus, while Ceylon (Badulla) very closely approaches that optimum from 9. p.m. to 9. a.m.

The shaded zone represents the range for optimum growth of the fungus in each of these graphs.

Kuala Lumpur, F.M.S., November, 1932.

PLATE


RAINFALL FOR KUALA
20.
15.
10.
5.
0.
115·4
76·4
96·3
1927
1928
1929


INCIDENCE OF MILDEW DISEAS
OF RUBBER
20.
10.
0.
1928
1929

1.

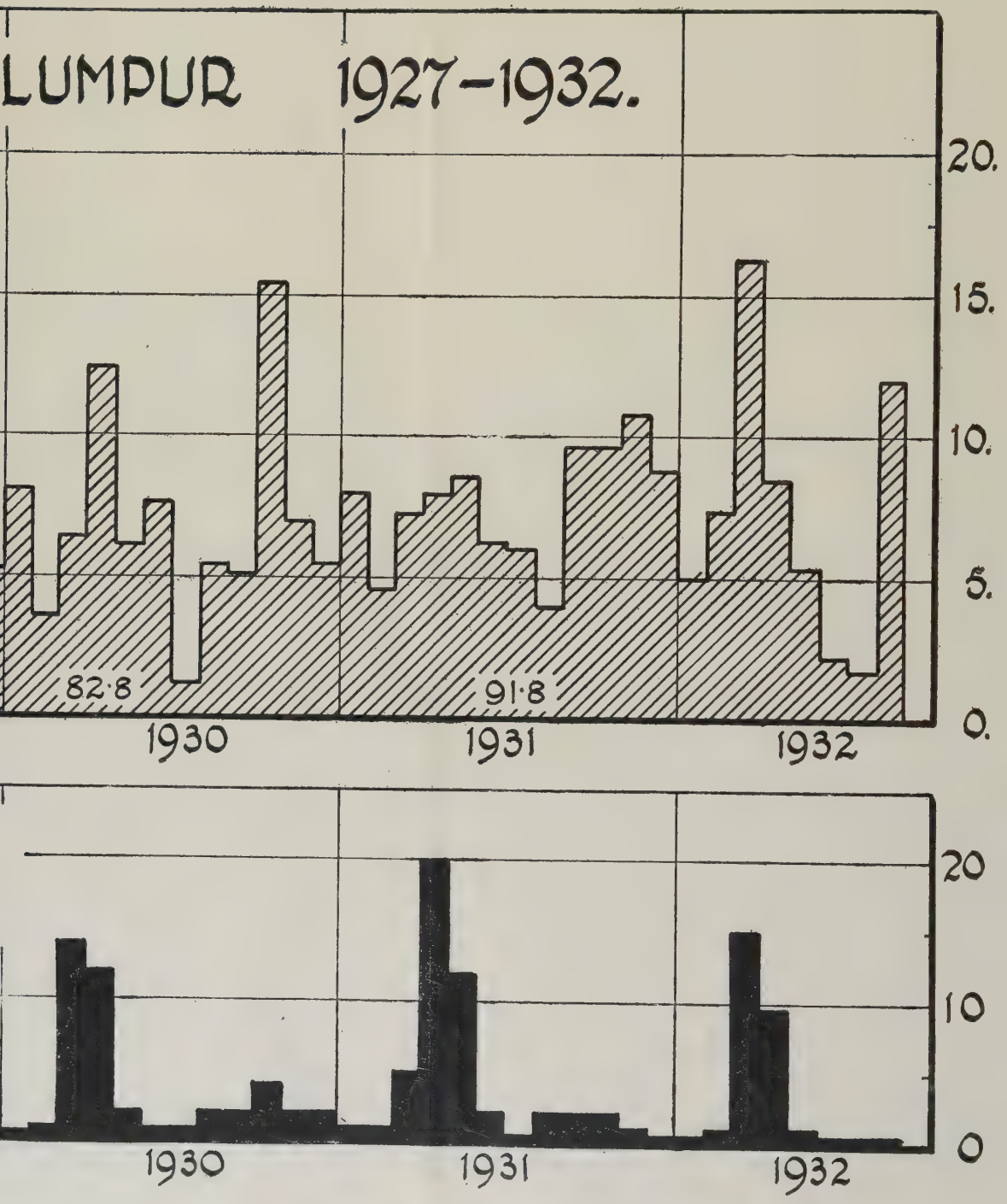
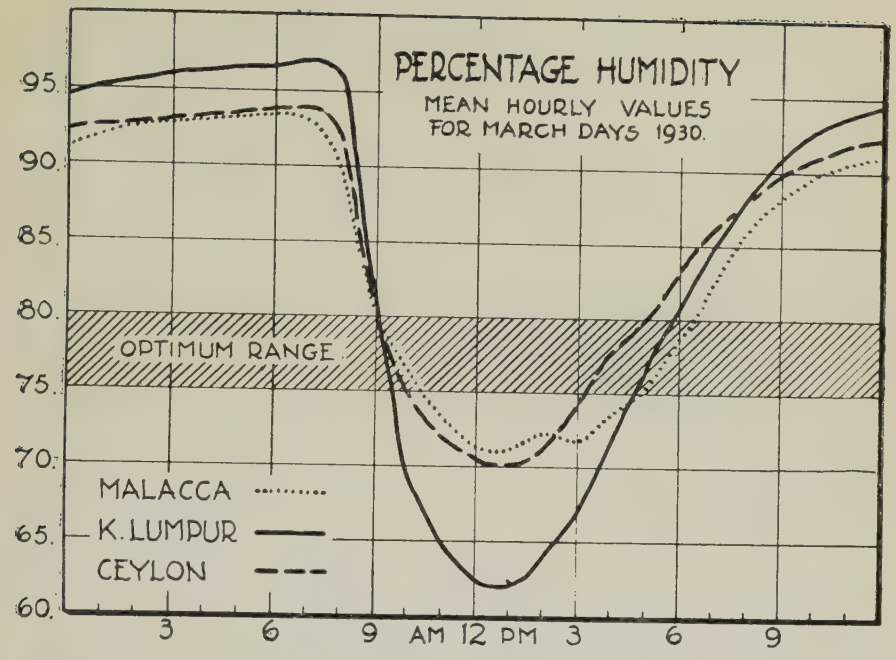
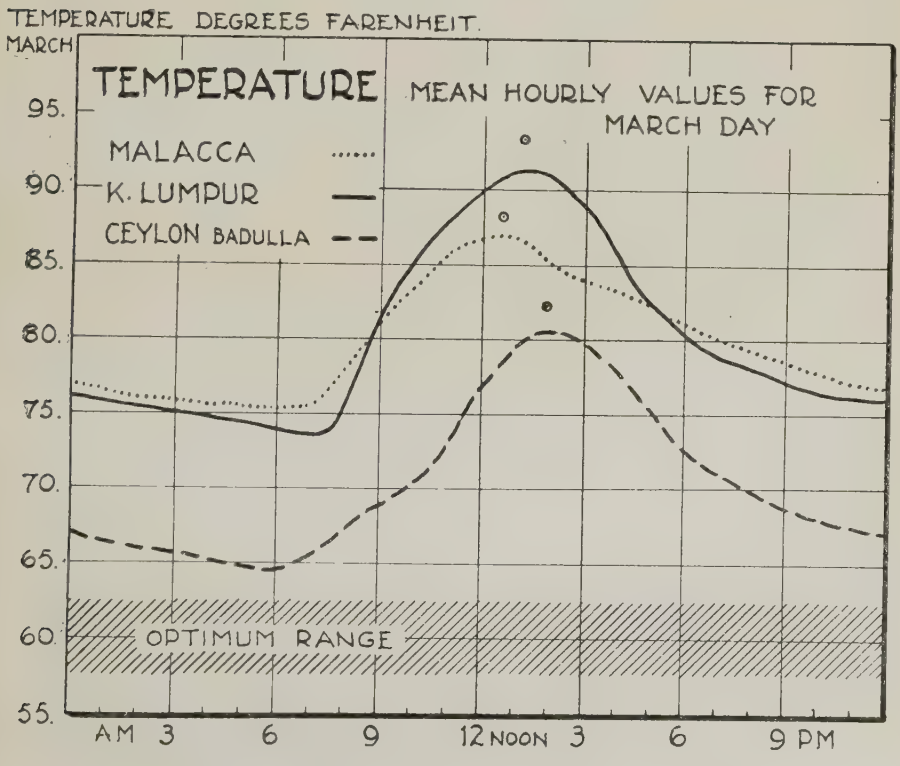

LUMPUR 1927–1932.
20.
15.
10.
5.
0.
82·8
91·8
1930
1931
1932
20
10
0
1930
1931
1932

PLATE 2.


PERCENTAGE HUMIDITY
MEAN HOURLY VALUES
FOR MARCH DAYS 1930.
95.
90.
85.
80.
75.
70.
65.
60.
OPTIMUM RANGE.
MALACCA
K. LUMPUR
CEYLON
3
6
9
AM 12 PM 3
6
9


TEMPERATURE DEGREES FAHRENHEIT.
MARCH
TEMPERATURE
MEAN HOURLY VALUES FOR
MARCH DAY
MALACCA
K. LUMPUR
CEYLON BADULLA
95.
90.
85.
80.
75.
70.
65.
60.
55.
OPTIMUM RANGE
AM 3
6
9
12 NOON 3
6
9 PM

REPORT ON SULPHUR DUSTING EXPERIMENTS.

BY

F. Beeley.

These experiments were designed with a view to obtaining some data regarding the costs and methods of control of the disease Heavea Leaf Mildew caused by the fungus *Oidium Heveae*. It has long been known that for rapid growth and spread, fungi of this, the powdery mildew type, are mainly influenced by suitable weather conditions. Such also seems to be the case with the rubber leaf fungus. Accordingly, any experiments planned must depend upon the presence of the fungus in the area and upon suitable weather conditions obtaining during the progress of the experiment.

Fairly dry weather, such as appears to be suitable to the growth of the fungus had been experienced during the months of January and February (1931) and though perhaps a little too much rain had fallen it was decided to carry out the experiments, as at that time, (February) the weather was promising fine.

A certain Rubber Company offered suitable areas for experimental purposes on their estate near Tampin. In addition the company supplied a dusting machine and several tons of sulphur, and it was decided to carry out the dusting experiments on that estate.

To obtain the necessary results and information regarding costs, efficiency and capabilities of a machine, experience in other countries indicated that blocks of not less than 100 acres for each unit of the experiment were advisable. Other factors such as the lie of the land, natural boundaries between blocks, general direction of prevailing winds, and road and transport facilities must also be taken into account when choosing the experimental blocks.

The estate was visited on February 16th. and 17th. and information regarding the lie of the land, prevailing winds, facilities for drying the sulphur and transport together with a plan of the estate were obtained. Twelve tons of sulphur (6 tons Flotate and 6 tons Mud-sulphur) were available and the following details of the experiment were suggested.

(a) In order to test the efficiency of the application of varying quantities of sulphur per acre the various blocks were to be dusted at the rate of 4, 7 and 10 lbs. per acre per dusting.

(b) It is possible that a preliminary dusting applied at the time when the old leaves are falling, and before the bursting of the new buds may be of considerable prophylactic importance. Accordingly two blocks, Blocks A & C were to be so treated.

(c) A comparison of the efficiencies of 'Mud' Sulphur which contains only 70 per cent pure sulphur against that of "Flotate" sulphur containing over 90 per cent pure sulphur was afforded in the general scheme.

(d) It was not expected that the adjustments of the machine would be such as would permit of an even application over one acre of a lesser quantity than 4 lbs. of Sulphur. An attempt, however, was made to get down to 3 lbs. per acre as suggested by Mr. Bjorklund during his visit to Malaya.

Unfortunately unsuitable conditions prevented the completion of the experiments, but below is given full details of the programme which it was intended to carry out at the time.

Experiment No.1. Block A. Field 2, area 70.75 acres. To be dusted 6 times at the rate of 10 lbs Mud-sulphur per acre per dusting. The first dusting to be given when the last of the old leaves begin to change colour and fall, the remaining 5 dustings will be given at intervals of 7 days commencing when the buds begin to burst and new leaves commence to form.

Total sulphur required 4,260 lbs.

Experiment No. 2. Block A. Field 3, area 103.89 acres. To be dusted 5 times at the rate of 10 lbs Mud Sulphur per acre per dusting. There will be an interval of 7 days between each dusting, the first being given as soon as the new leaves begin to form.

Total sulphur required 5,200 lbs.

Experiment No. 3. Control Area. Block B. Area 203 acres. This plot being of a similar type of soil, and similar age class of rubber will serve as control area for Experiments 1 and 2.

Experiment No. 4. Block C. Fields 1, 2 and 3, area 151.26 acres. To be dusted 6 times at the rate of 7 lbs Flotate sulphur per acre per dusting. The first dusting will be given when the old leaves begin to change colour and fall off. The remaining 5 dustings will be given at intervals of 7 days commencing when the buds begin to burst and new leaves commence to form.

Total sulphur required 6,353 lbs.

Experiment No. 5. Block C. Fields 4 and 5, area 100 acres will serve as control area.

Experiment No. 6. Block C. Fields 6, 7 and 8, area 184 acres. To be dusted 5 times at the rate of 7 lbs Flotate Sulphur per acre

per dusting. There will be an interval of 7 days between each dusting, the first being given as soon as the new leaves begin to form.

Total sulphur required 6,440 lbs.

Experiment No. 7. Block C. Fields 9, 10 and 11, area 180 acres will serve as control area for Experiment No. 8.

Experiment No. 8. Block C. Fields 12 and 13, area 120 acres. To be dusted 5 times at the rate of 4 lbs. Mud Sulphur per acre per dusting. There will be an interval of 7 days between each dusting the first being given as soon as the new leaves begin to form.

Total sulphur required 2,400 lbs.

Experiment No. 9. Block D. All fields, total area 144 acres: This block in reality is representative of clean weeded Small Holding rubber, having been recently purchased from the native owners. This area is to be dusted 5 times at the rate of 3 lbs. Mud Sulphur per acre per dusting, the first application being given as soon as the new leaves begin to form.

Total sulphur required 2,200 lbs.

POINTS TO BE INVESTIGATED.

(1) Costs of treatment, sulphur, labour, oil, transport etc. for each experimental block.

(2) Capacity of machines, and methods of dusting.

(3) Relative efficiencies of Mud Sulphur and "Flotate" Sulphur.

(4) Effect of the sulphur treatment on foliage and fruit.

(5) Effect of the sulphur treatment on yield.

(6) Effect of applying different quantities of sulphur per acre.

(7) Presence or absence of the fungus *Oidium Heveae* in both treated areas and controls, before, during and after experiments. Degree of virulence (Leaf-fall, crinkled leaves, setting fruit etc.) in the different blocks.

(8) Effective radius and distribution of sulphur from the machine under (a) calm, (b) windy, (c) flat land, (d) hilly land, conditions.

(9) Weather conditions at the time.

DESCRIPTION OF THE DUSTING OPERATION AND RESULTS.

On March 2nd., dusting was commenced on Block C, Experiment 8. Two lots of 16 lbs of sulphur were weighed out and used for the purpose of adjusting the machine and speed of

travelling. It was found that a drift of 140 yards could be allowed for, and the machine was adjusted to put out 16 lbs over a walking distance of 140 yards. i.e. approximately 4 lbs per acre. In crossing bunds or silt pits the rate of flow of sulphur would be irregular: later, a better method of carrying the machine was devised and this largely avoided this irregularity of flow on uneven ground. It was also of advantage in crossing plank bridges, the men walking always in single file. The work of carrying the machine is very strenuous and 20 to 30 mins. is ample for one shift, the men working in alternate shifts carrying the machine and carrying the sulphur. The sulphur was carried in specially cut kerosene tins, each holding 32 lbs. when about 1" from full, and in this manner an easy though rough means of estimating the rate of flow of sulphur from the hopper was provided. Two such tins of sulphur could be carried "kandar" fashion by one cooly. The carrying of sulphur in sacks from the dump to the machine was found to be most unsatisfactory and wasteful of sulphur and time. During the first few days of work the engine often became overheated and stopped, and therefore the lubricating oil and petrol mixture was varied from 1 in 8 to 1 in 16. A 1—12 mixture was found to be most suitable, but to be on the safe side it was decided to stop the engine for 10 minutes after each one hour's work, in order to allow the engine to cool. Burning sulphur on the metal vanes of the engine prevents efficient cooling.

It was found possible to dust ravines from some convenient point either at the top or at the mouth according to the direction of drift.

A test of the drift of sulphur dust was made by depositing the machine on the ground and pouring out about 10 lbs of sulphur in the one place. Though the air was comparatively calm the cloud of sulphur drifted visibly 200 yards from the machine. If a strong breeze is blowing this distance can be exceeded, but it was noticeable in such cases that the sulphur was carried well above the trees and out of sight.

Overfeeding the sulphur into the fan chamber gives a very poor cloud of dust; incidentally a great amount appears granular and rapidly falls to the ground after leaving the funnel. This is especially so if either the sulphur or the atmosphere are damp. Dust cloud formation is mainly dependent on (a) the dryness of the sulphur, (b) the rate of feed of sulphur to the fan, and (c) the speed of the engine.

The sulphur was dried on the concreted site of an old shed some 12 × 18 ft. which had been repaired and made smooth with cement. This site was large enough to dry 3 sacks i.e. 660 lbs. of sulphur in 3½—4 hours of bright sunshine and dry atmosphere. A

bright morning following rain did not seem to dry the sulphur. It was partly because of our inability to get the sulphur dry that the dusting was subsequently stopped. The low hanging cloud of sulphur and actual falling sulphur made the work extremely unpleasant for both coolies and supervisor.

It was particularly noticeable on certain days of bright sunshine, yet damp atmosphere, that sulphur which had been exposed on the concrete floor to "dry", when put through the machine, dusted worse than sulphur taken direct from the sack as originally packed. This was remarked upon by the coolies themselves.

The effect of adding powdered lime to the sulphur to act as a drying agent was not tried.

The 'Flotate' sulphur possessed better physical properties as a dust than "Mud Sulphur" in that it

1. appeared to be drier,
2. formed a more intense cloud which would hang about the trees for 2 or 3 minutes,
3. contained less of the granular material which could usually be observed falling near the machine when "Mud" Sulphur was being dusted.

A further point which had to be guarded against was the tampering with the controls by the coolies. Having set out with the day's quantity of sulphur the coolies tried to get rid of it as quickly as possible; besides lifting up the damper they were also observed pushing the sulphur into the machine regardless of the fact that most of it fell to the ground immediately after leaving the funnel. Also when the "shift" was changing over the tendency was to put down the machine and have a long argument as to whose turn it was to carry it next, meanwhile the machine would still be pouring out sulphur.

During the 16 days March 2—18, rain fell on 9 days and on two occasions actually interfered with the day's dusting. The fungus was not present on young leaves and flowers and it was not possible to dry the sulphur in the open. Hence it was decided to stop the experiment, since no useful pathological information could be derived therefrom. At this time some 1,200 acres of dusting had been carried out.

It was found that 250—300 acres could easily be dusted in an 8 hour working day. It was not of any advantage to start early in the morning as the atmosphere then is in its most humid state and the sulphur will not rise. Dusting should start at about 8.a.m. and be continued till 5 p.m. if rainy weather does not intervene.

Hence if dust is applied every seven days the capacity of one machine should be 2,100 acres per season. It is on this assumption that an estimate is given of the probable costs of dusting in Malaya based on the actual costs found during the experiments.

Costs of Sulphur Dusting.

Estimated for the dusting of an area of 2000 acres at similar rates to those obtained during the above experiments.

1.	Oil—Petrol 165 gals. @/77 per gal.	= $128.59
	Lubricant 16.5 gals. @ $2/90 per gal.	= 48.43
		177.02
2.	Labour 12 coolies for 36 days @ -/50	= $216.00
3.	European Supervision.	= $125.00
4.	Depreciation 33% of cost of machine	= $214.00
	Total.....	= $732.00
	Rate per acre per single dusting	= 7.32 cents

Total cost of treatment = 7.32 times the number of dustings given plus cost of the weight of sulphur desired per acre in cents.

Dusting 10 lbs per acre five times. @ 7 days intervals, Sulphur price 6 cents per lb. = $7.32\times5+10\times5\times6=32.6+300$ cents
= $3.36

Similarly 5 dustings at the rate of 7 lbs Flotate Sulphur per acre give a total cost of $2.46 per acre.
Similarly 5 dustings at the rate of 5 lbs Flotate Sulphur per acre give a total cost of $1.86 per acre.

Interval between dustings.

After the final dustings of Experiment Nos. 1 & 2 on March 18 (dusted 3 times at 10 lbs. per acre) the Manager of the Estate states he noted the presence of the disease on the 9th. April. On visiting the estate it was found that occasional late wintering trees were infected in the lower branches and a small amount of leaf-fall was taking place, despite the fact that the weather was showery throughout the refoliation period. In the other experiments the 7 lbs per acre blocks showed a slight increase of Oidium as compared with the 10 lbs per acre block, the 4 lbs per acre block a greater increase still and in fact when the hill was viewed closely some trees were completely diseased and had apparently been infected for several days. It seems reasonable therefore to infer that a period considerably shorter than 3 weeks is desirable for the interval between dustings; it is suggested that not more than 7—10 days' interval is necessary to ensure complete control.

In regard to the quantity of sulphur per acre per dusting, it was evident from the foliage of the 10 lbs. per acre block that a

large measure of control had been accomplished while the 4 lbs. per acre blocks were almost indistinguishable from the control undusted blocks. It would seem therefore that 7—10 lbs per dusting is necessary to maintain 10 days' prophylactic effect.

A point which appears worthy of notice is that the average field of rubber developed from seed contains so many different types of trees that buds will be found opening at different times over a long period. Thus when dusting during refoliation, buds opening after a round of dusting produce leaves which are without protection as no sulphur will have been deposited on them. They will therefore be open to attack until the next application of dust in that area. This fact in itself necessitates shorter intervals between dustings.

In the case of budded areas, it is noticeable that areas planted with mixed clones give fields of rubber which occupy a long period of wintering and refoliation and these, if diseased, must be treated over a long period as in the case of seedling areas.

If, however, an area is planted with a single clone, then all trees of that clone having the same characteristics, the wintering and refoliation will take place over a shorter period of time, fewer dustings will be necessary, and the cost of treatment per acre will be proportionately low.

Summary.

An outline is given of the plan of the experiments and the data which it was hoped each part of the experiments might produce.

A description of the method of dusting and the difficulties met with both in the mechanics of dusting operations and in the two varieties of sulphur dust used, is included.

Costs have been reckoned on the basis of the probable number of dustings, weight of sulphur used, supervision, labour and oils as found during these experiments.

Unsuitable weather rendered the experiments difficult of execution and of little pathological value. Hence the dusting was stopped as no further benefits could be derived from further expense in their continuation.

Acknowledgment.

I should like to express my appreciation of the very valuable assistance given to me by Mr. J. R. Tannock, Manager of the estate and by Messrs Boustead & Co. Ltd.

DESCRIPTION OF PLATE.

Photograph of the Bjorklund dusting machine showing the method of carrying while in action.

Note. By this method the coolies walk in single file while the two point rope suspension gives a proper distribution of weight and greater stability of the machine necessary to ensure a constant rate of flow of sulphur dust.

Kuala Lumpur, F.M.S., November, 1932.

ON THE EFFECT OF COVERS AND CULTIVATION METHODS ON THE GROWTH OF YOUNG RUBBER. III.

BY

W. B. Haines.

In two previous reports (R.R.I. Journal Vol. 3, Nos. 1 and 2) the differences in growth of young Hevea trees at the R.R.I. Experiment Station have been discussed. The ages of the trees at the dates of these two series of measurements were one year and two and a half years respectively. The present paper follows up the developments in these same experiments by two further series of measurements at ages 3 and 3½ years, and introduces one or two new experiments. For the older rubber we have at this stage discarded the attempt to measure height and spread of each tree as being too cumbersome, and have adopted instead the more practicable measurement of girth as the index of growth.

Blocks 7 and 8—Covers.

These blocks afford comparisons of trees growing under covers of Calopogonium, Crotalaria and Leucaena (Lamtoro) and under clean weeded conditions on ground which has been cleared (Block 8) and on ground with the timber left (Block 7). Table I gives the results of girth measurements made at 1 foot above the ground. As on previous occasions examination of the records began with the drawing up of a size-distribution curve and the rejection of those members which fall outside the normal class, (i.e. supplies etc.)

Since the experiment was laid down its history has been disturbed (1) by digging in half the Calopogonium after 9 months growth, (2) by pulling out half the Crotalaria and Lamtoro in October 1931, (3) by budding alternate trees in part of Block 8. In spite of this we may conclude from the table that Calopogonium and Crotalaria are still retarding growth of the rubber to about the same extent as before, i.e. 14 per cent. The Lamtoro plots, on the other hand, have now caught up to the adjacent controls, which points to some definite advantage in this cover as compared with the others. The difference between the two blocks is so small as to show that the presence or absence of lying timber is so far without importance.

TABLE I.

Average girth in inches at 1 foot above ground.

		Block 7 Timber left lying			Block 8 Timber cleared		
		3 years.	3½ years	Growth in 6 months	3 years	3½ years	Growth in 6 months
Calopogonium	Seed at Stake	13.18	15.56	2.38	12.30	14.98	2.68
	Baskets	13.56	16.55	2.99	12.13	15.02	2.89
	Stumps	12.70	15.13	2.43	12.75	15.74	2.99
	Average	**13.15**	**15.86**	**2.70**	**12.39**	**15.25**	**2.86**
Control	Seed at Stake	14.05	17,24	3.19	13.32	16.55	3.23
	Baskets	14.70	17.99	3.29	15.55	18.61	3.06
	Stumps	15.30	18.16	2.86	14.81	18.16	3.35
	Average	**14.68**	**17.79**	**3.11**	**14.55**	**17.77**	**3.22**
Crotalaria	Seed at Stake	11.48	13.65	2.17	11.42	13.96	2.54
	Baskets	13.40	16.22	2.82	12.79	15.88	3.09
	Stumps	12.43	15.19	2.76	12.92	15.85	2.93
	Average	**12.43**	**15.02**	**2.59**	**12.37**	**15.23**	**2.86**
Control	Seed at Stake	13.60	16.78	3.18	13.97	17.45	3.48
	Baskets	15.60	18.49	2.89	16.12	17.96	1.84
	Stumps	14.00	17.09	3.09	14.77	19.53	4.76
	Average	**14.40**	**17.45**	**3.05**	**14.95**	**18.31**	**3.36***
Lamtoro	Seed at Stake	13.28	16,56	3.28	14.01	17.64	3.63
	Baskets	14.38	17,53	3.15	13.63	17.19	3.56
	Stumps	14.20	17.05	2.85	16.07	19.64	3.57
	Average	**13.95**	**17.05**	**3.10**	**14.57**	**18.16**	**3.59***
Control	Seed at Stake	14.32	17.52	3.20	14.20	17.54	3.34
	Baskets	15.25	18.47	3.22	14.59	19.97	5.38
	Stumps	16.81	19.62	2.81	16.16	18.14	1.98
	Average	**15.46**	**18.54**	**3.08**	**14.98**	**18.55**	**3.57***

There is little difference between the three types of planting material, but there is a slight tendency for the seed-at-stake figures to be lower than those for basket plants and stumps.

* Half the trees in this section were budded, and consequently a slight benefit is shown in these figures for the remaining trees from the check of competition.

The effect of pulling out half-strips of the Crotalaria and Lamtoro was as follows after nine months :—

Crotalaria, average on undisturbed half	14.45 inches
„ „ pulled „	15.72 „
Difference	1.27 inches
Lamtoro, average for each half	17.00 inches
Difference	Nil

A similar comparison was made between the half-strips of Calopogonium, giving :—

	Block 7.	Block 8.
Average girth on undisturbed strip	15.54	14.61
„ „ strip dug at 9 months and regenerated	16.25	15.90
Difference	1.29 ins.	.71 in

It thus appears that the effects of competition of the cover may be ameliorated by digging or pulling. In the case of Lamtoro, where the effects of earlier competition have now disappeared, the pulling gave no improvement.

Block 11.—Trees in belukar.

The history of this block indicates a further falling behind in development as compared with standard clean-weeded plots. The figures are given in Table II.

TABLE II.

Average girth in inches at 1 ft. above ground.

	Block 11 Planted 22 x 22			Block 11 Planted 22 x 11			Planted same season as Block 11 Clean weeded areas	
	3 years	3½ years	Growth	3 years	3½ years	Growth	Block 7	Block 6
Slashed	12.21	13.36	1.15	11.82	12.98	1.16	3 yrs. 14.84	13.99
Unslashed	11.97	12.94	.97	11.43	11.94	.51	3½ „ 17.93	16.82
							Growth 3.09	2.83

The figure which clearly indicates the position is the average growth over the last six months. Under these belukar conditions the increase in girth is only one third that of the clean weeded blocks over the same period. Slashing every six months has had some slight effect in improving the growth, but the difference is not a radical one. There can be no doubt that this block has entered upon a phase of delayed growth, after having done well in the earlier stages. This is a most important result, but requires a good deal of supplementary data for its interpretation. The relative position is likely to last for a considerable time. The uncontrolled half is to be left for observation of its further history, but it is intended that the slashed half of this block shall be changed over to selective weeding. This will then afford evidence on the controversial question as to the importance to be attached to the kind of undergrowth permitted.

Block 6.—Manuring.

The results on this block have hitherto been reported separately, but as the last measurements show no change in the course of events, they merit no special comment and are here simply put on record.

TABLE III.

Block 6.

Girth in inches at 1 foot above ground.

Plots	A	B	C	D	E	F
	Control	Dung	Complete inorganic	N. only	N. & P.	P. & K.
3 years	13.99	15.16	14.65	14.21	14.06	14.34
$3\frac{1}{2}$ „	16.82	18.12	17.59	17.10	17.04	16.99
Growth	2.83	2.96	2.94	2.89	2.98	2.65

The dung plots maintain the lead, but none of the differences are of a magnitude to be important. It is interesting to note the high degree of accuracy which this experiment possesses. The standard error has been reduced at each successive series of measurements (expressing the tendency for inequalities to even out as growth proceeds) and for the last series its value was 1.29 per cent. This is a very low value for any field experiment, and means that effects of a magnitude as low as 3 per cent can be established with certainty.

The measurements on this block have proved a remarkable capacity of recovery in trees which made a very poor and slow start. The first reports (R.R.I. Journal, Vol. 1, No. 4; Vol. 2, No. 1) revealed the fact that, beginning soon after planting, a large proportion of the trees stagnated for a period covering two wet seasons. The conditions were so bad that the delayed plants would have been replaced by supplies in the second year if their numbers had not been so large. Practically all of these trees finally made good growth, as shown in the following table.

TABLE IV.

	Delayed Class	Normal Class
Average height at 12 months:	under 3 feet	over 5 feet
„ „ „ 15 „.	3½ „	8½ „
„ „ „ 30 „	20 „	23 „

The striking thing is that trees which lagged behind till their handicap was at least a year's growth should catch up to and in many cases surpass the others in the ensuing year or eighteen months. The effect is as though there had been in some way an accumulation of "potential" during the suppressed period which was later released. The averages do not bring out the full effect, for the behaviour of the individual trees was that they started growth again suddenly but at different times. It is quite certain therefore that the rate of growth of these delayed trees after release was above that for the normal class when the latter were in the same stage of development. This behaviour would correspond to such effects as the partial sterilisation of the soil (which might well be produced in patches of soil during clearing and burning operations), which gives a period of enhanced fertility following a period of depression. But explanation along such lines based on external factors are difficult when it is borne in mind that these delayed trees were fairly evenly distributed over all the plots, i.e. the incidence was not radically affected by any of the fertiliser treatments. It is unlikely, for instance, that the application of dung should have failed to correct a stagnation due to soil sterilisation or any simple nutritional lack. The explanation therefore remains a mystery at present. The fact that size of tree in the later stage depended so much more on actual age than on period of vigorous growth indicates that internal factors might be included in the consideration.

Block 17 A. Covers and Manures.

This area had a complete fertiliser over the whole at planting. Two strips are clean weeded and two are under a very vigorous growth of Centrosema pubescens. The original planting 22 x 22 feet has been budded; there are also later interplanted seedlings bringing the

stand to 22 x 11 ft. These interplants suffered a serious retardation from the cover, which was planted at the same time. Thus at eighteen months the average height of these seedlings on the cover strips was 7.5 feet or 30.2 per cent. behind the average height on the clean weeded strips (10.8 feet). Later at twentythree months of age the retardation was still 26.5 per cent. (average heights 10.0 feet and 14.9 feet). The budded plants, representing the original planting, suffered a smaller retardation of 12.0 per cent, which is of a magnitude similar to other experiments. These trees had six months start before the cover was planted. The figures at 2½ years were :

Average height of buddings under cover	9.1 feet
,, ,, ,, ,, clean weeding	10.3 ,,

The manuring test on this block was designed for a complete fertiliser in two different amounts and at two different frequencies of application. As in the case of Block 6 the result so far is negative for any practical purpose.

Block 17 D.—Covers.

These plots represent the same planting as in 17 A and are under strips of various covers.

TABLE V.

Average height in feet of buddings (2½ years—15 months budded) and interplanted seedlings (23 months).

	Buddings.	Seedlings.
Lamtoro ...	7.09	14.09
Tephrosia ...	6.42	12.80
Crotalaria ...	6.65	12.69
Mimosa ...	4.81	11.59
Mikania ...	6.17	12.23
Pueraria ...	6.06	11.25
Calopogonium ...	4.33	11.11
Centrosema plumeri ...	5.70	12.35
,, pubescens ...	5.70	10.77
Vigna (poor growth) ...	7.89	14.20

The growth of the Vigna was so poor that the plot could almost be regarded as a clean weeded control. Lamtoro shows up favourably, as it has done on Blocks 7 and 8. Mimosa, on the other hand shows unfavourably. On the seedlings, Centrosema pubescens, Calopogonium and Pueraria, all show up unfavourably, this effect being associated with their vigour of growth and hence of competition.

Block 19.—Cultivation.

This experiment is a block of nine plots, being three treatments in triplicate to test the effect of periodical deep cultivation of the soil.

The area was under natural grasses for the first two years. The subsequent treatments of the plots is to be, (1) grasses maintained, (2) grasses dug in and then clean weeding followed, (3) grasses dug in twice yearly and regenerated in the interval. The first series of measurements were taken seven months after the first digging and gives the following table. The budded plants correspond to two budding rounds.

TABLE VI.

	Average heights in feet		
	Buddings.		Interplants.
	First round	Second round	Not budded
Controls maintained	13.54	7.16	7.14
Dug in and weeded	14.39	7.22	7.26
Dug in and regenerated	14.05	6.98	7.89

It appears too early to make much comment on these figures. It may be that the retarding effect of the drastic digging and the following benefit from the cultivation about balance at this stage.

Block 24.—Erosion experiment.

This experiment was started at the request of the Experiment Station Committee on the steep side of Bukit Nibong Gila. Strips running down the hill were marked out for the planting of various covers, and hard wood posts were sunk at intervals to act as index marks for soil movement. They originally had exactly 30 inches above the soil surface and were spaced down the middle of each strip so that one came on every terrace and one halfway between terraces. The results of the first measurements after twenty months are given in Table VII. The index marks were below the surface for most of the posts, which perhaps only indicates a little settlement in the case of posts on the hillside between the terraces.

TABLE VII.

Average inches of burial of index marks—erosion experiment.

	Posts between terraces.	Posts on terraces.
Calopogonium	.12	2.22
Pueraria	.54	4.36
Indigofera	.12	4.44
Crotalaria	.37	6.18
Vigna	.84	5.23
Centrosema	.24	5.46
Tephrosia	.60	5.52
Grasses	.12	4.99
Weeded	.12	7.49

Taken in conjunction with the vigor of growth (i.e. the degree of cover afforded) these figures only serve to demonstrate in more precise terms the effects to be expected from general considerations. The weeded plot shows the most movement, while Calopogonium which has afforded the most complete cover shows the least movement, its presence having reduced the wash to less than one-third. The erect growing covers show up poorly as a check on wash and the creepers fall very much into the order of their vigor and degree of spread.

SUMMARY.

Measurements are recorded for the growth of young Hevea trees under various conditions of cultivation.

Most covers have produced some retarding effect, the magnitude depending upon factors which determine the degree of competition. Lamtoro stands out as producing the least effect in this regard.

Trees grown in belukar, whether slashed periodically or uncontrolled, are, in their fourth year, making much slower growth than trees on the areas with normal clean weeding or covers.

Comment is made upon the ability of trees which suffered a prolonged delay in their early growth to catch up in later stages and make good their handicap.

Kuala Lumpur, F.M.S., November, 1932.

THE CARBON AND NITROGEN CONTENTS OF SOME NATURAL COVERS.

BY

C. G. Akhurst.

Introduction.

The practice of growing a cultivated cover plant with rubber trees is generally accepted in Malaya as a sound policy in estate management, and it is well supported by scientific theory and experiment. The main benefits derived from a cover plant are that (a) erosion losses are reduced to a negligible amount, (b) soil temperature is kept down and its limits of variation are restricted, (c) soil moisture relationships are improved, and (d) the organic matter content of the soil is maintained.

The growth of cultivated covers on rubber estates is so far restricted to leguminous plants, but this practice is by no means universal throughout the country. Many estates are clean-weeded, whilst many others have a cover of growths which are termed "natural" covers. In the latter cases, the attempt to establish a cultivated leguminous cover has probably proved either too expensive or else so unsuccessful as to be ineffective, and the "natural" cover is one or other of the plant growths which appear naturally on the cessation of weeding. The natural cover which appears is often found to be extremely varied, and it may be presumed that it will be best to encourage certain plants (from the point of view of ultimate benefit to the soil) whilst suppressing other varieties: in other words, to weed selectively. A correct basis for this selection is one of the pressing present-day problems.

A broad distinction between natural covers for selective weeding can be made by encouraging the growth of non-woody types, which have soft stems and which grow large green leaves. This undoubtedly gives a satisfactory basis for selection on very general lines, and is based entirely on general observations and experience in the field. Results from controlled experiments which will give closer distinctions between species are not yet available, and it is suggested, as a preliminary means of approach to the problem of obtaining a finer classification of plants for selective weeding, that a study of carbon and nitrogen contents of natural covers will be of considerable value. Certain covers have therefore been selected and the carbon and nitrogen contents are recorded here.

EXPERIMENTAL.

The following is a list of the plants taken for analysis :—

1. *Lycopodium cernuum* (Stagmoss, staghorn fern); the sample was taken from an area of moderately thick growth of stagmoss, and the plant as a whole was analysed.

2. *Gleicaena linearis,* (bracken); the sample was taken from an area adjacent to the above, where the growth of bracken was moderately thick. For analysis, stems and leaves of the plant were taken separately.

3. *Paspalum conjugatum* (cattle grass); the sample was taken from an area of thick growth of cattle grass, and grass leaves and stalks were analysed separately.

4. *Melastoma polyanthum* (Straits, or Singapore, rhododendron); the sample was taken from an area containing a very mixed growth of natural covers in which a fair amount of the rhododendron occurred. The plant selected was not too woody, and leaves and stem were analysed separately.

5. *Nephrolepis biserrata* (fern); the sample was taken from an area adjacent to the previous one, and leaves and stalk were analysed separately.

6. *Loganiaceae, Fagraea. sp. racemosa*; samples of mature leaves of this plant were available for analysis. It is one of the so-called "coffee-family" plants.

7. *Hevea brasiliensis,* (rubber seedling); a number of self sown rubber seedlings, averaging about 18 inches in height, which were collected over an area growing stagmoss and bracken, formed the sample. The stems and leaves were analysed separately.

8. *Hevea brasiliensis,* (rubber tree leaves); the sample consisted of mature leaves collected from rubber trees growing on an area containing an undergrowth of bracken and stagmoss.

9. *Centrosema pubescens* (leguminous, cultivated cover); the sample consisted of mature plants, before seeding, taken from an area of young, immature rubber. Leaves and stalks were analysed separately.

10. *Calapogonium mucunoides* (leguminous, cultivated cover); the sample consisted of mature plants, before seeding, taken from an area adjacent to the previous one. Leaves and stalks were analysed separately.

11. Peat; the sample was taken from a typical area of peat, over the surface foot, for purposes of comparison.

The plants in all instances were specimens of normal healthy growth, with leaves of a good green colour, and they may be considered as typical of the particular plants.

In most cases the moisture contents of the fresh samples were determined, and the carbon and nitrogen figures were determined on the oven-dried (at 100°C.) sample. Robinson's (1) wet combustion method with sulphuric acid (absorption of sulphur dioxide in standard iodine solution) was used for the carbon determination, and the nitrogen was determined on the residue from the sulphuric acid digestion by a micro-Kjeldahl method. Duplicate determinations were always made, good agreement being obtained between different duplicates. The following tables give the results.

TABLE I.

Plant Leaves.

	Moisture %	Carbon %	Nitrogen %	Ratio : $\frac{\text{Carbon}}{\text{Nitrogen}}$
Lycopodium cernuum. Stagmoss (whole plant)	298	46.6	2.23	20.9
Gleicaena linearis. Bracken.	89	46.6	2.41	19.3
Paspalum conjugatum. Cattle grass.	100	36.2	2.45	14.8
Melastoma polyanthum. Straits rhododendron.	138	44.5	2.28	19.5
Nephrolepis biserrata. Fern.	301	39.4	1.98	19.9
Hevea brasiliensis. Seedling.	232	52.7	4.23	12.5
Hevea brasiliensis. Mature tree.	150	55.0	3.65	15.1
Loganiaceae. Fagraea sp. racemosa.	208	52.0	2.50	20.8
Centrosema pubescens. Leguminous.	—	46.4	4.38	10.6
Calapogonium mucunoides. Leguminous.	—	45.9	4.47	10.3
Peat.	327	47.6	1.45	32.8

(All figures are calculated on the oven dry weights.)

TABLE II.

Plant Stems.

	Moisture %	Carbon %	Nitrogen %	Ratio: $\frac{\text{Carbon}}{\text{Nitrogen}}$
Lycopodium cernuum. Stagmoss (whole plant)	298	46.6	2.23	20.9
Gleicaena linearis. Bracken.	63	47.05	0.807	58.3
Melastoma polyanthum. Straits rhododendron.	157	41.0	0.717	57.1
Nephrolepis biserrata. Fern.	203	44.6	1.67	26.7
Paspalum conjugatum. Cattle grass.	49	43.6	1.43	30.5
Hevea brasiliensis. Seedling.	—	48.3	2.30	21.0
Loganiaceae Fagrea sp. racemosa.	176	47.9	1.105	43.4
Centrosema pubescens. Leguminous.	—	43.1	3.03	14.2
Calapogonium mucunoides. Leguminous.	—	43.6	2.52	17.3
Peat.	327	47.6	1.45	32.8

(All figures are calculated on the oven dry weights.)

The results show that for the leaf materials of the non-leguminous plants, carbon and nitrogen figures were very similar, with the C : N ratios all approximately 20 : 1. Cattle grass and rubber leaves (particular young ones) were exceptions here, the nitrogen content of leaves from rubber seedlings being practically the same as the figure for leaves from leguminous covers. This figure (4.23%) is quite remarkable and is almost twice the amount found in the other natural covers. The C : N ratio for cattle grass leaves was much lower than the average, being 14.8 : 1.

The figures for plant stalks indicate fairly uniform values for the carbon content (about 45%), with considerable variations in the nitrogen contents. The stems of the rubber seedlings again have a high value (2.3%) closely approaching that of the cultivated leguminous covers (2.5 to 3%), whilst the woody stems of the Straits rhododendron and of bracken have very low nitrogen figures, round about 0.7 to 0.8%.

Discussion.

Before dealing with the above results, it will be necessary to consider the process of decomposition of plant materials in the soil. Published data on such decompositions deal almost entirely with green manuring, that is to say, with a crop that is mechanically incorporated with the soil by digging in, and obviously a different state of affairs exists where cover plants are grown under rubber. No digging in is done, and plant material is incorporated in the soil solely by fallen leaves, twigs, stems, etc., alighting on the soil surface and gradually drying and being pressed into the soil by further additions of debris, or by movements of earthworms, etc. The conditions therefore approximate closely to ordinary forest conditions, but in both instances, with green manuring and with forest conditions, the general mechanism of decomposition of plant residues is similar, and results obtained with green manuring may be applied, in a general way, to forestry conditions.

The decomposition of plant materials is brought about entirely by micro-organisms, mostly soil fungi and bacteria, and they utilise organic matter added to the soil as a source of supply for both energy and nutrients. Part of the added carbon is resynthesised, together with some of the nitrogen and other mineral nutrients, into microbial body substances, and any residues from the plant material help to form humus in the soil, the excess nitrogen being liberated mainly in the form of nitrates. Plant material will undergo this series of changes, sooner or later, whether it is incorporated in the soil (green manure) or whether it merely forms an accumulating debris on the soil surface (forest conditions), though factors which affect the rate of change have great importance.

The most important limiting factor is the composition of the plant with respect to carbon and nitrogen. The carbon compounds in plant materials, when added to the soil, are an immediate source of energy to soil micro-organisms and at once a considerable increase in microbial activity takes place. At the same time, the organisms require further nutrients in the form of nitrogen and inorganic radicals, and as far as possible they utilise nitrogen from the proteins in the plant material, whilst the soil normally has ample supplies for their other inorganic requirements. The assimilation of carbon

and nitrogen by soil bacteria and fungi proceeds along definite fixed lines; for each unit of carbon taken in a definite amount of nitrogen is also needed by the organisms. If sufficient nitrogen is not available in the plants, the micro-organisms will consume any nitrogen in the soil (present as nitrates) for furthering the decomposition of the plant remains, and thus a competition with the growing crop may be set up, with marked adverse effects. If soil nitrogen too is unavailable, a considerable slowing up of the decomposition of the plant organic material occurs. When a supply of nitrogen in excess of the needs of the bacteria and fungi is present in the plants, the excess is liberated as nitrates, in the soil, and becomes available to the plants.

The results (2) of experiments with temperate climate soils show that the limiting figure for the nitrogen content of plant material is just under 2% (about 1.8%). That is to say, when plant material decomposes in the soil and contains 2% or more of nitrogen, decomposition proceeds fairly rapidly, with a liberation of nitrates which are immediately available for plant food. If the nitrogen content is much below 2% decomposition will only proceed slowly, and there will be an actual loss of available nitrogen from the soil.

Further work, (3) has also shown that the carbon:nitrogen (C:N) ratio of the added material, in conjunction with the reaction of the soil, has considerable influence on the amount of nitrification which takes place. For neutral to alkaline soils in temperate regions, pH 6.5 to 7.0, a C:N ratio of less than 20-25 to 1 is required in order to produce nitrification, and in acid soils, pH 4.5 to 5.0, the ratio is much smaller, 13-18 to 1. Thus, neutral soils are more favourable to rapid decomposition of plant remains than acid soils.

In brief, there are optimum values for the carbon and nitrogen contents of decomposing plant materials, under specific conditions of temperature, soil acidity, etc., at which decomposition proceeds most economically—the plant remains disappear entirely, microbial activity is at a maximum, no depletion of available nitrates in the soils occurs, and there is a steady addition to the soil humus supply. If the nitrogen figure exceeds its optimum value, the soil benefits from the extra nitrate which becomes available as plant food, although whether this is used by growing plants or is lost in drainage water depends entirely on circumstances.

In applying such results to natural covers growing under rubber various specific conditions must be considered. Since the covers do not come into such intimate contact with the soil as they would do if they were dug in, several effects will be produced. Only the bottom layer of debris, immediately touching the soil, will be affected by soil organisms, and the upper layers will tend to dry out. Drying out (3) will affect the future decomposition of this material, since normally the soluble organic substances in plant residues decompose

first, followed by pentosans and celluloses, the lignin constituents being least easily decomposed and tending to accumulate in the soil. The drying out of the upper layers, which will proceed to a considerable extent in more open areas, tends to convert the soluble hemicelluloses into less soluble forms, which will have an appreciable retarding effect on the rate of decomposition. Hence, whenever slashing of natural covers is done, pressing of the cut material onto, and into, the soil is of considerable importance.

The effect of soil acidity in lowering the maximum C : N ratio in plant material at which nitrification will occur in the soil will be particularly evident in Malayan soils, which almost without exception, are acid, pH 4.5 to 5.5. Under acid conditions, the activities of bacteria are suppressed, whereas fungi are able to flourish, and the predominance of fungi in Malayan soils, both on rubber estates and in jungles, has already been recorded (4). Since fungi in the decomposition of organic materials, synthesise more nitrogen than bacteria do into their protoplasm, their influence on nitrification of plant remains will be readily appreciated and understood, since this microbial protein nitrogen remains unavailable to plants until the organisms themselves are decomposed. Experimental results on Malayan soils are not available to show what is the limiting figure for C : N ratio of plant materials in order to give nitrification on decomposition. The total numbers of micro-organisms (4) are considerably lower than in temperate region soils, and considering this, together with the acidity of local soils, it would appear probable that a C : N ratio of considerably less than 18 : 1 (the upper limit in acid North European soils) is the maximum permissible if nitrification is to take place during decomposition of the plant remains.

Recent work on the types of humus layer in the forests of Northeastern United States (5), (6) in dealing with the distinctions between mull and duff types, shows that it is not the *rate* of decomposition, but the *type* of decomposition of forest litter which differentiates these two main classes of forest humus layer. Determinations of nitrate content gave values in crumb mull averaging twice as much as those for root duff, but there was no definite correlation between acidity and nitrification. [Crumb mull is defined as a coarse grained mull, inhabited by numbers of large earthworms, mull being a porous, more or less friable, humus layer of granular structure. Duff is defined as a humus layer of unincorporated humus, strongly matted or compacted, and distinctly delimited from the mineral soil].

With regard to the actual nitrogen content of covers, because of the part played by fungi in the decomposition of plants in Malaya, a figure slightly higher than that obtained in temperate regions (1.8%) would seem to be the minimum necessary for nitrification. Further, the relatively high rainfall of Malaya will tend to reduce the "effect-

iveness" of the nitrification. That is to say, when nitrificaton of plant residues occurs, the proportion of nitrates taken up again by growing plants will tend to be lower than in temperate climates because of the losses of nitrate which taken place through leaching. Hence,a greater production of nitrates is required for plant growth, which is another factor tending to raise the minimum value for nitrogen content of plant materials.

The following table gives the various plants arranged in order of nitrogen contents.—

TABLE III.

Leaves			Stems		
%N	Plant	C/N	%N	Plant	C/N
4.47	Calopogonium ...	10.3	3.03	Centrosema ...	14.2
4.38	Centrosema ...	10.6	2.52	Calopogonium ...	17.3
4.23	Rubber seedlings	12.5	2.30	Rubber seedling	21.0
3.65	Mature Rubber	15.1	2.23	Stagmoss ...	20.9
2.50	Loganiaceae ...	20.8	1.67	Fern ...	26.7
2.45	Cattle grass ...	14.8	1.45	Peat ...	32.8
2.41	Bracken ...	19.3	1.43	Cattle grass ...	30.5
2.28	Rhododendron ...	19.5	1.10	Loganiaceae ...	43.4
2.23	Stag-moss ...	20.9	0.81	Bracken ...	58.3
1.98	Fern ...	19.9	0.72	Rhododendron ...	57.1
1.45	Peat ...	32.8			

The leaves of the stagmoss, bracken, rhododendron, cattle grass and loganiaceae specimens all contain slightly more than 2% nitrogen, and consequently cannot be expected to produce much nitrate nitrogen on decomposition. The rubber leaves, however, and the legume leaves, both have ample nitrogen to give good nitrification on decomposition. In the stems, the nitrogen contents are slightly above the 2% figure for the rubber seedlings and legumes (stagmoss was analysed as a whole plant), and for the remainder the figures are well below 2%, and for bracken and rhododendron less than 1%.

The C : N ratios for stems and leaves fall into a similar sequence of classification (with the one exception of cattle grass leaves) thereby emphasizing the advantage enjoyed by the legumes and rubber seedlings over the other plants, from the point of view of potential nitrate production. The decomposition of the other plant leaves, with nitrification, could be considerably aided by the reduction of

soil acidity (i.e. liming the surface soil layer). For these plants, the proportion of stem to leaf material would seem to be a limiting factor, because of the low nitrogen content of the stems. Where a considerable stem growth is produced, decomposition in the soil will be slow and there is a possibility that nitrogen losses from the soil will occur. From this point of view, bracken and rhododendron are the two least useful of the natural covers.

It must be realised that the plants have been considered solely from the point of view of their carbon and nitrogen contents, and that other characteristics may have definite additional influences in deciding the suitability of a plant as cover. Thus, general growth habit, leaf production, rooting habit, shading effect on soil, transpiration, moisture content, ease of introduction and control, etc., are other factors which need to be taken into account and these require carefully planned field experiments for complete elucidation.

Summary.

1. Carbon and nitrogen contents of various plant ("nature" and cultivated covers) are recorded.

2. These results are discussed with a view to deciding the ultimate relative benefits to the soil produced by the growth of such covers.

References.

(1) Robinson, G. W. McLean, W. and Rice Williams, *Jour. Agric. Sci.*, 1929, **19,** 315.
(2) Jensen, H. L. *Jour. Agric. Sci.*, 1929, **19,** 71.
(3) Waksman, S. A. and Tenney, F. G. *Soil Science,* 1927, **24,** 317.
(4) Corbet, A. S. *J. Rub. Res. Ins. Malaya,* 1931, **3,** 5.
(5) Romell, L. G. *Soil Science,* 1932, **34,** 161.
(6) Romell, L. G. and Heiberg, S. O. *Ecology,* 1931, **12,** 567.

Kuala Lumpur, F.M.S., 31st October, 1932.

THE PROPERTIES OF CLONE RUBBER.

Part I.

J. L. Wiltshire and R. G. Fullerton.

In view of the very considerable amount of bud-grafted rubber which is due to come into bearing within the near future a knowledge of the properties of clone rubber is becoming increasingly desirable. The acquisition of such knowledge is severely handicapped by the difficulty of obtaining authentic samples of rubber from the various proved clones, and an exhaustive study of the subject must await the production of the rubber in marketable quantities.

Although the study of rubber from all the well-known clones is at present impossible, the facilities at our disposal do permit some preliminary investigations, the earliest of which is now reported. The object of this investigation has been to determine whether there is a significant difference between the rubber from four clones of known history. No attempt has been made at a comparison between clone rubber and normal seedling rubber.

The mother-trees of the clones studied are situated on Pilmoor Estate and the original buddings were carried out on the same Estate by the scientific officers of the Rubber Growers' Association prior to the formation of this Institute. The yielding powers of the mother trees have been recorded by Sanderson and Sutcliffe (This Journal Vol. I. (1929) 151) and the early history of the clones may be found in the Bulletins of the Rubber Growers' Association (1924-1927). More recently, complete records have been kept by the Botanical Division of this Institute and references have been made to their progress in the Annual Reports for 1928 to 1931.

The age of the trees in tapping is from 6½ to 7 years. Tapping is conducted on the alternate daily system. The cut is on the half circumference and is a left to right spiral at an angle of about 35°. The height of tapping is from 8 to 12 inches above the union of scion and stock, and the time of tapping is from 6.30 to 8 a.m.

The rubber from each day's tapping was tested separately in order to determine the degree of daily variation in the rubber from each clone as well as monthly averages. This necessitated the examination of about sixty samples a month and rendered impossible anything approaching a complete examination of every sample. It was therefore decided to adopt the single figure which is normally used in this laboratory for purposes of comparison and determination of variability. This figure is the tensile modulus at a given elongation, for a rubber/sulphur mix cured under standard conditions for a given

time (see Bishop and Fullerton, this Journal Vol. III. 129). The modulus is expressed in kilograms per square millimetre for an elongation of 650 per cent, and the time of cure depends on the type of rubber which is under examination. As explained below it was found necessary in this instance to use a cure of 60 minutes for the first period of three months and of 80 minutes for the second period of three months.

The experiments were commenced on July 16th, 1931 and the technique adopted was maintained unaltered until the end of September, 1931. A minimum quantity of sodium sulphite was used in the field and the latex was conveyed as quickly as possible from the Estate to the Institute Laboratories. It was there coagulated with acetic acid and the coagulation was allowed to proceed overnight. On the following morning it was sheeted, dripped, and dried in a hot-air chamber maintained at a temperature of 110°—120° F. When vulcanisations were carried out it was found that a time of cure of 60 minutes was most suitable. At this time of cure nearly all samples gave a reasonably high modulus and very few rings broke i.e. very few samples were overcured. At a time of cure of 70 minutes many samples were overcured whereas at 50 minutes many were definitely undercured. Two rings were pulled from each sample and of 148 samples examined during the period there were only five instances where both rings broke before reaching an elongation of 650%. In these instances the break occurred at an elongation of about 600%, and in order to facilitate mathematical comparison of the figures these curves were produced and a figure obtained for a 650% modulus by extrapolation. It is considered that the inaccuracy thus introduced is of less importance than the complications which would arise from the complete omission of these five figures.

From October 1st, 1931, it became necessary to alter the experimental conditions as far as they affected the method of preparation. It was found impossible to continue the expensive and troublesome practice of bringing the latex from the Estate to the Institute, and arrangements were made for the coagulation to be carried out at Pilmoor under the direction of the manager. Aluminium pans were used for coagulation, and the rubber was sheeted and smoked according to normal factory procedure. The smoked sheet was then sent to the Institute for vulcanisation under the conditions described above. On the early samples the rubber/sulphur mix was cured over a range of 60 to 90 minutes and finally 80 minutes was adopted as the standard time. In view of the change in the method of preparation, the slowing down of the rate of cure cannot be regarded as any indication of a change in the nature of the rubber, and the two periods must be considered quite separately. Certain variations in estate procedure during the month of November rendered the samples received for this month liable to suspicion and they were accordingly rejected

without being tested. The second period consists of the months of October and December, 1931, and January, 1932. As far as is known the procedure during these months was quite uniform within the limits of normal factory practice.

Variation between Clones.

The complete series of tensile moduli are given in Table I (A and B). In order to facilitate comparison, monthly averages have been calculated and are quoted in Table 2. The greatest divergence is found in the month of July when the coefficient of variation was plus or minus 11 per cent of the mean value of that month. The coefficient of variation for the whole of the first period was plus or minus 8 per cent and for the second, plus or minus 4 per cent. Since the month of July included only eight tappings out of a total of 80 it may be said that, as the general rule, the variation does not exceed plus or minus 10 per cent.

A true conception of the relative magnitude of this variation is obtained by comparison with figures obtained under similar conditions from ordinary seedling rubber. Thus Bishop and Fullerton (loc. cit.) give the figures obtained from the smoked sheet produced by 48 different estates. The tensile modulus for 650 per cent elongation after 80 minutes cure was determined for each sample and the coefficient of variation was found to be plus or minus 24 per cent. It must be pointed out that this variation arises not only from differences in the actual rubber produced by the various groups of trees but also from differences in manufacturing methods on the various estates. Unfortunately no figures are available for the examination of samples from different estates, all manufactured under the same conditions. Table 3 gives another set of figures reported by Bishop and Fullerton. The rubber from four estates was tested in August and in November, 1931, and the tensile moduli showed variation of 16 and 25 per cent respectively.

It may therefore be said that, as far as this particular property is concerned, the difference between the rubber from the four clones, all of which is prepared under the same conditions, is about one-half of the differences between ordinary rubbers from various estates each of which use their own methods of preparation.

Variations within the Clones.

Reference to Table I shows that the coefficient of variation of the moduli figures within any one clone ranges from 19 to 24 per cent in the first period, and from 14 to 15 per cent in the second. For purposes of comparison, samples of normal rubber from Pilmoor Estate were examined over a portion of the period under

consideration. These samples were prepared under the same conditions as the clone rubber and should therefore give a true indication of the relative variation amongst the rubber actually obtained from the trees. The samples used for this purpose were not representative of the whole estate, but were always derived from the same block of trees, situated near the clone rubber. The figures are given in Table 4 and it will be seen that the coefficient of variation (over 25 days) was 19 per cent, i.e. of the same order as the figures given by the clones.

The variation within each clone is not significantly smaller than the variation in the samples from a neighbouring division of ordinary rubber.

Similarity in Variation.

A superficial examination of Table I discloses certain days on which all four clones give high moduli and other days where all four clones give low moduli. Examples of such days are :—

July 28	—	1.27, 1.12, 1.00, 1.28
July 30	—	.53, .42, .55, .75
August 9	—	1.42, 1.28, 1.25, 1.22
August 31	—	.79, .56, .60, .67
January 4	—	1.09, 1.14, 1.10, 1.13
January 28	—	.61, .80, .84, .84

This indicated a certain similarity between the mode of variation of the four clones and suggested that the factors influencing the quality of the rubber were, on some occasions at least, operating simultaneously and similarly on all the trees concerned. This point has been made clearer by the construction of graphs and by a mathematical investigation of the degree of correlation.

The graphs (Figures 1 and 2) show a considerable degree of parallelism between the four individual curves. This is further stressed by the "banded" curves (Figures 3 and 4) which are formed by joining all the daily maxima as the upper limit and all the daily minima as the lower limit.

From each of the two periods correlation coefficients have been calculated for all the possible pairs of clones. The results are given in Table 5. All the pairs give positive correlation, and with one exception—A44—B84, second period—the coefficients represents a very high level of significance for the number of samples considered.

It has already been shown that the daily variations within each clone are definitely larger than the variation between monthly averages of all the clones, and it is now established that these variations depend mainly on factors external to the tree. There can be no definite statement as to the nature of these factors but they may probably be looked for amongst the following :

(1) Atmospheric temperature and its mode of variation throughout the day:

(2) Rainfall and its time of incidence:

(3) Amount and time of incidence of direct sunlight:

(4) Small variations in time of tapping:

(5) Small variations in method of tapping:

(6) Daily variations in soil conditions.

All these factors can act on the course of the synthesis of the rubber in the tree; some can act also on the rubber after it leaves the tapping cut. Climatic conditions may have considerable effect on the rubber on the bark and in the cup. The outstanding example is the possibility of variation in the amount of premature coagulation due to variation in climatic conditions. It is almost certain that such coagulation is selective as regards the non-rubber constituents of the latex and may therefore have a direct influence on the general properties of the residual uncoagulated rubber.

It is hoped that an opportunity will arise for the closer study of these factors in an effort to determine which of them, if any, are the controlling factors. From the practical standpoint it remains that the variation does exist and is probably largely due to factors outside human control.

The work on these four clones is proceeding pending the arrival of marketable quantities of rubber from the more widely used clones. It is proposed to extend the study to the other properties of rubber and, in particular, to the ageing properties.

Summary.

(1) From the aspect of the one criterion adopted, the difference in quality between monthly averages of the four clones is small.

(2) The daily variations within each clone are of the same order as within a series of samples from a stand of ordinary rubber on the same estate.

(3) The daily variations of the four clones show a high degree of correlation and are to be attributed mainly to factors external to the trees.

TABLE 1A.

Tensile Moduli of Vulcanised Clone Rubber.

First Period—July, August, September.

Time of Cure 60 minutes.

Clone		Tensile Modulus in Kgs/sq. mm. for elongation of 650 per cent.			
		A44	B16	B58	B84
July	16	1.03	1.00	0.98	0.72
	18	0.95	0.80	0.88	0.98
	20	0.85	0.63	0.89	1.17
	22	1.00	0.98	0.57	1.32
	24	1.01	0.89	0.85	0.91
	26	1.18	0.54	0.95	1.23
	28	1.27	1.12	1.00	1.28
	30	0.53	0.42	0.55	0.75
August	1	1.28	0.91	0.75	0.68
	3	1.10	0.50	0.64	0.83
	5	1.07	0.70	0.92	0.78
	7	0.64	0.77	0.83	0.85
	9	1.42	1.28	1.25	1.22
	11	1.17	0.95	0.92	1.15
	13	1.04	1.01	0.92	1.22
	15	0.69	0.96	0.81	0.97
	17	0.85	0.72	0.94	0.72
	19	0.90	0.77	0.52	1.04
	21	1.42	1.28	1.02	1.22
	23	0.89	0.62	0.68	0.71
	25	1.03	0.78	0.79	0.98
	27	1.11	1.28	1.09	0.87
	29	0.70	0.72	0.91	0.94
	31	0.79	0.56	0.60	0.67
September	2	1.18	1.04	1.02	1.22
	4	0.66	0.74	0.78	0.81
	6	1.06	0.83	0.74	0.95
	8	1.18	0.99	1.08	0.99
	10	0.94	0.82	0.91	1.04
	12	1.02	0.73	0.74	0.93
	14	1.15	1.05	0.93	1.12
	16	1.12	0.77	1.09	0.95
	20	1.02	1.14	0.71	0.81
	24	1.02	0.78	0.67	0.72
	26	1.18	1.14	0.96	1.22
	28	1.16	0.85	0.77	1.03
	30	0.92	0.81	0.76	0.70
Mean ...		1.01	0.86	0.85	0.96
Standard Deviation ...		0.19	0.21	0.17	0.19
Coefficient of Variation		19%	24%	20%	20%

TABLE 1B.

TENSILE MODULI OF VULCANISED CLONE RUBBER.

Second Period—October, December, January.

Time of Cure 80 minutes.

Clone		Tensile Modulus in Kgs/sq. m.m. for elongation of 650%			
		A44	B16	B58	B84
October	4	0.88	0.92	0.95	0.91
	6	0.79	0.82	0.83	—
	8	0.67	0.97	0.87	1.03
	10	0.69	0.72	0.63	0.72
	12	0.75	0.76	0.68	0.79
	14	0.86	0.73	0.74	0.79
	16	0.81	0.82	0.75	0.90
	18	0.73	0.75	0.66	0.81
	20	1.08	0.65	0.72	0.70
	22	1.00	0.80	0.72	0.80
	24	0.72	0.80	0.70	0.69
	26	0.94	0.74	0.65	0.69
	28	0.76	0.83	0.81	0.78
December	1	0.95	0.93	0.75	0.90
	3	0.84	0.89	0.82	0.93
	5	0.59	0.66	0.68	0.81
	7	0.79	0.87	0.73	0.98
	9	0.88	0.78	0.73	0.81
	11	0.64	0.85	0.76	0.90
	13	0.68	0.56	0.67	0.76
	15	0.75	0.78	0.68	0.77
	19	0.74	0.86	0.69	0.94
	21	0.64	0.70	0.58	0.77
	23	0.81	0.99	0.77	0.97
	25	0.81	0.77	0.83	0.90
	27	0.94	0.95	0.90	0.94
	29	0.89	0.96	0.80	0.79
	31	1.00	0.94	0.83	1.05
January	2	—	0.79	0.78	0.86
	4	1.09	1.14	1.10	1.13
	6	0.74	0.72	0.89	0.91
	8	0.85	1.09	0.95	1.23
	10	1.01	0.99	0.98	0.84
	12	0.78	0.84	0.91	0.82
	14	0.97	0.94	0.91	0.94
	16	0.86	0.92	0.85	0.92
	18	0.75	0.72	0.71	0.73
	20	0.83	1.05	0.87	0.89
	22	0.89	0.99	0.85	0.88
	24	0.81	0.91	0.71	0.92
	26	0.80	0.71	0.84	0.88
	28	0.61	0.80	0.84	0.84
	30	1.02	0.96	0.98	1.08
Mean ...		0.82	0.85	0.79	0.87
Standard Deviation ...		0.12	0.12	0.11	0.12
Coefficient of variation ...		15%	14%	14%	14%

TABLE 2.

MONTHLY AVERAGES.

Tensile Modulus in kilograms per sq. mm. for elongation of 650 per cent.

First Period—60 minutes cure.

Clone	A44	B16	B58	B84	Mean	Standard Deviation	Coefficient of variation
July ...	0.98	0.80	0.83	1.04	0.91	0.10	11
August ...	1.01	0.86	0.85	0.93	0.91	0.06	7
September ...	1.05	0.90	0.86	0.96	0.94	0.09	10
Mean ...	1.01	0.86	0.85	0.96	0.92	0.07	8

Second Period—80 minutes cure.

Clone	A44	B16	B58	B84	Mean	Standard Deviation	Coefficient of variation
							Per cent.
October ...	0.82	0.82	0.77	0.80	0.80	0.02	3
December ...	0.80	0.83	0.75	0.88	0.82	0.05	6
January ...	0.86	0.90	0.88	0.93	0.89	0.03	3
Mean ...	0.82	0.85	0.79	0.87	0.83	0.03	4

TABLE 3.

COMPARISON OF NORMAL SHEETS FROM FOUR DIFFERENT ESTATES.

(From Bishop and Fullerton. This Journal Vol. III 1932 p. 137.)

Tensile Modulus in kilograms per sq. mm. for elongation of 650 per cent.

Time of cure 80 minutes.

Estate	No. 1	No. 2	No. 3	No. 4	Mean	Standard Deviation	Coefficient of variation.
							Per cent.
August ...	0.69	0.79	0.60	0.94	0.75	0.12	16
November ...	0.58	0.42	0.67	0.87	0.64	0.16	25

FIGURE 1. DAILY VARIATIONS OF TENSILE MODULUS

JULY, AUGUST, SEPTEMBER. 60 M

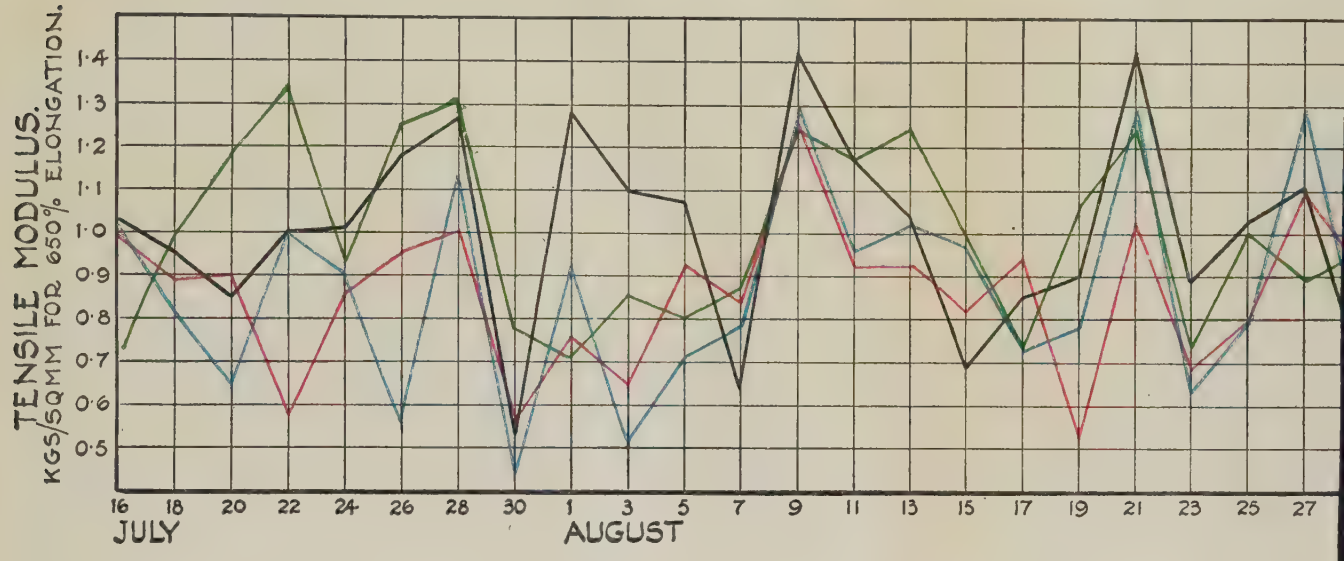
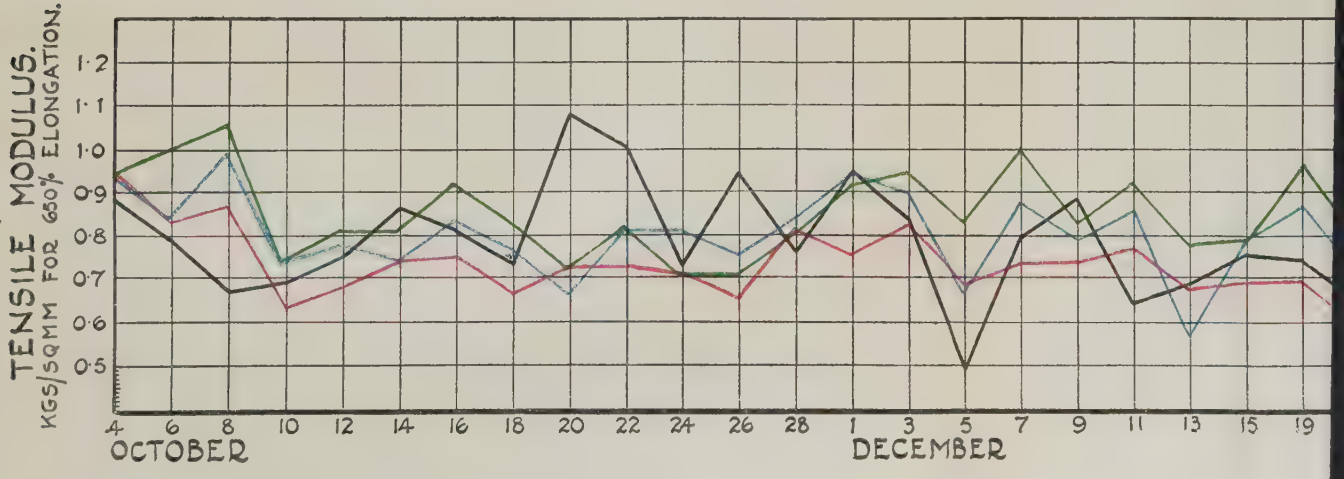
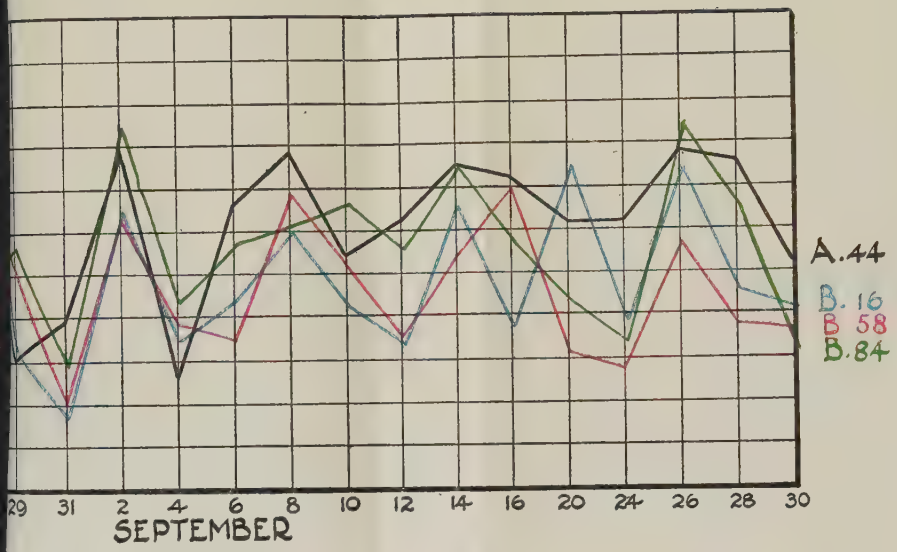


FIGURE 2. DAILY VARIATIONS OF TENSILE M

OCTOBER, DECEMBER, JANUAR



OF VULCANISED RUBBER.
NUTES CURE.



ODULUS OF VULCANISED RUBBER.
Y. 80 MINUTES CURE

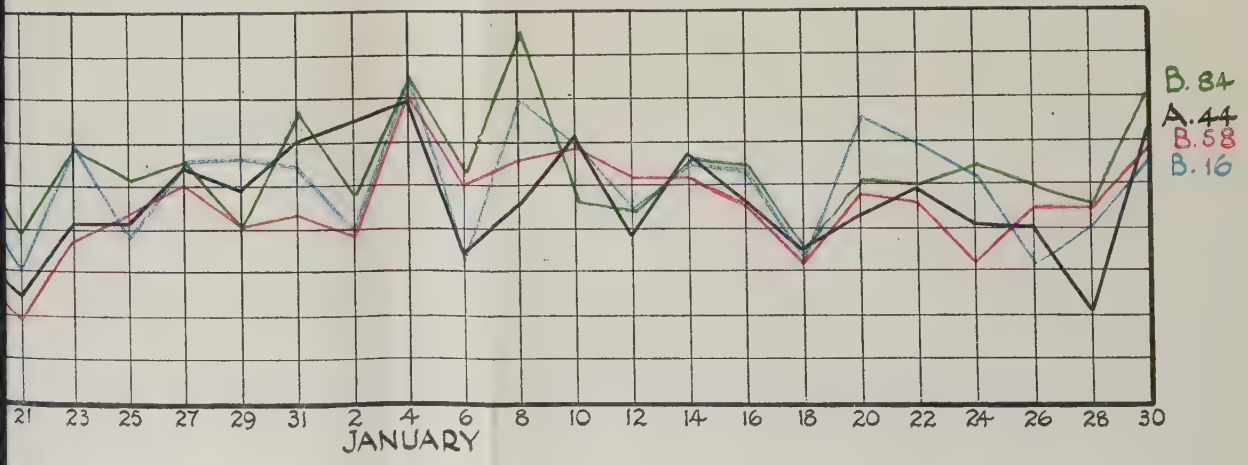


FIGURE 3.

DAILY MAXIMA AND MINIMA O
JULY, AUGUST, SEPTEMBER. 6

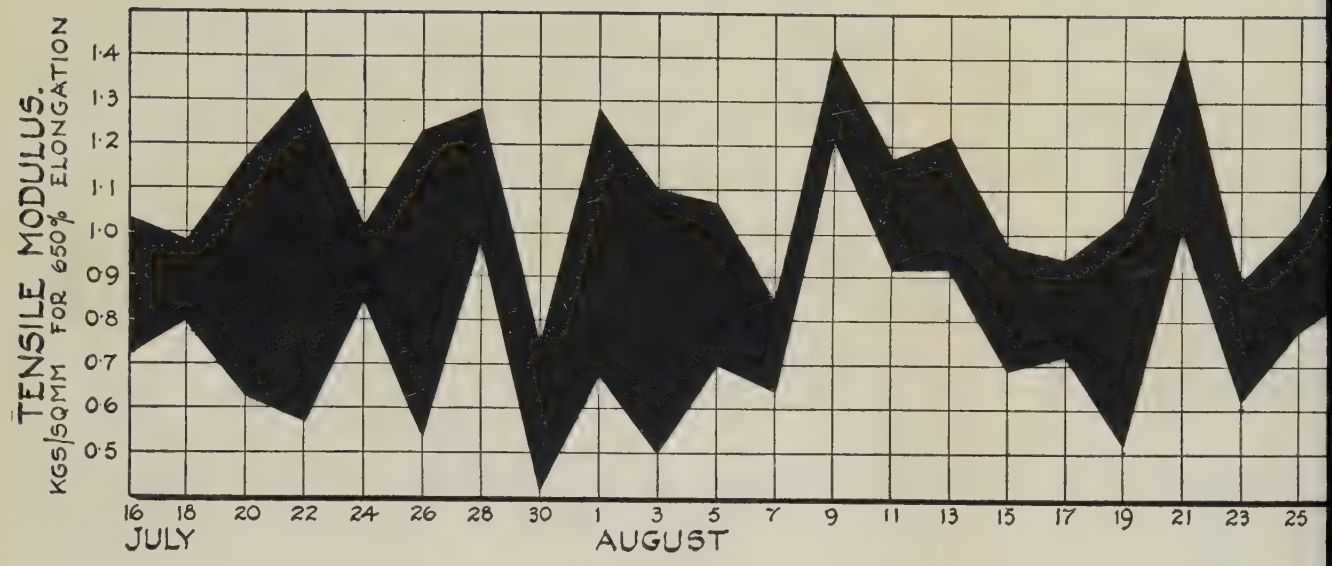
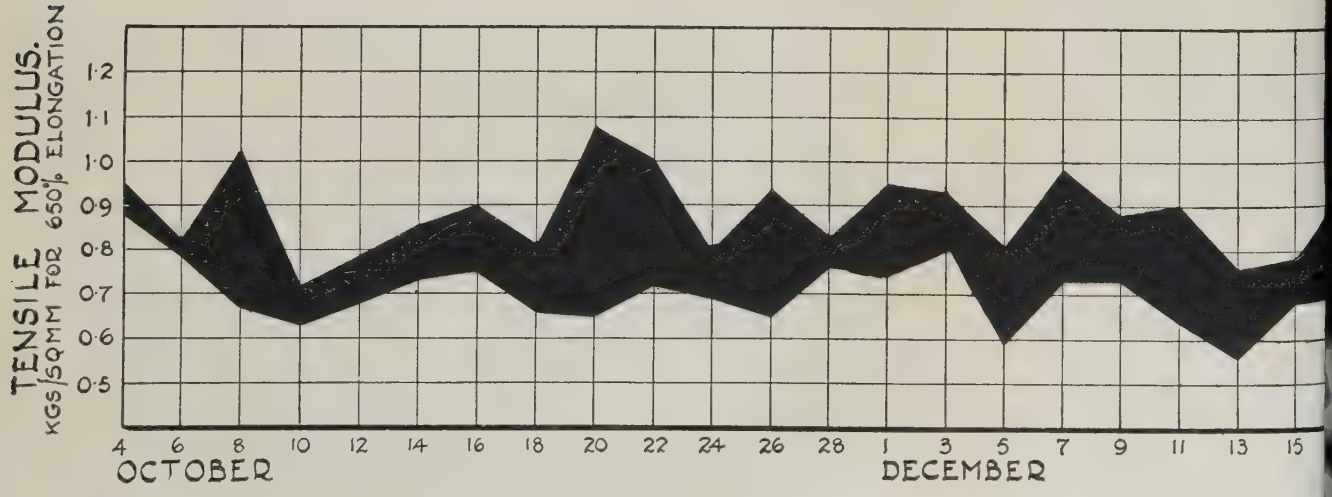
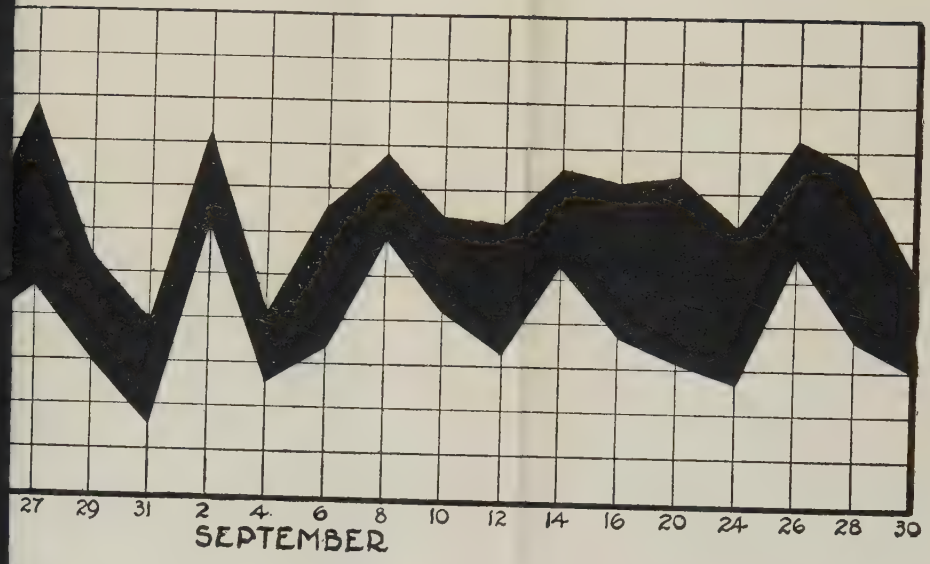


FIGURE 4.

DAILY MAXIMA AND MIN
OCTOBER, DECEMBER, JANUA



F TENSILE MODULI.
0 MINUTES CURE.



MA OF TENSILE MODULI.
RY 80 MINUTES CURE.

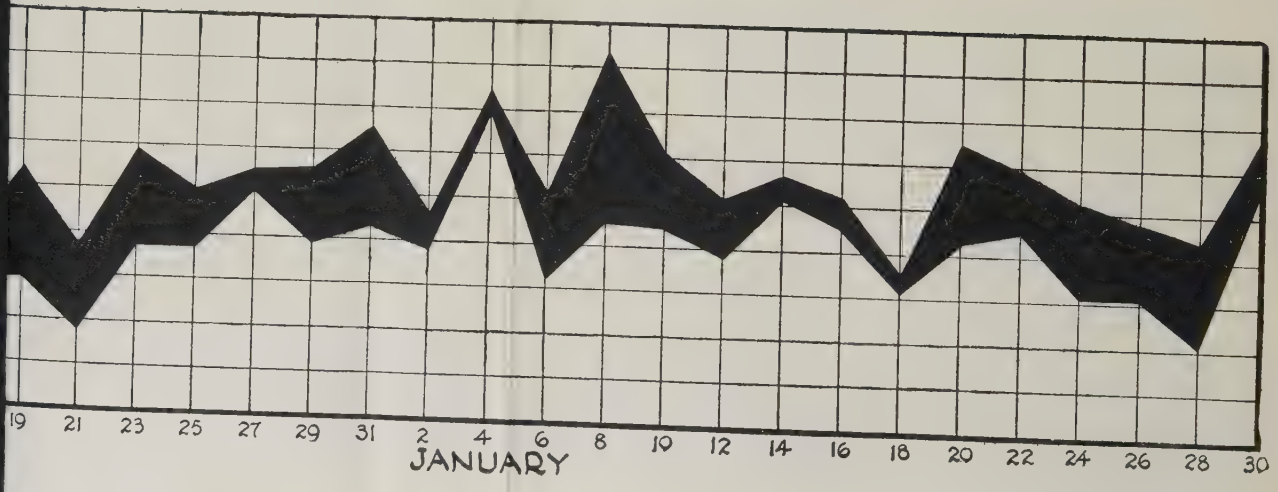


TABLE 4.

VARIATION IN NORMAL RUBBER FROM PILMOOR ESTATE.

Tensile Modulus in kilograms per sq. mm. for elongation of 650 per cent.

Time of cure 80 minutes.

Date	Kgs/sq. mm. for 650% elongation	Date	Kgs/sq. mm. for 650% elongation
December 2	0.89	January 9	0.95
4	0.82	11	1.14
6	0.67	13	0.85
8	1.13	15	0.76
10	1.13	17	0.81
12	1.01	19	0.85
14	0.63	21	1.11
16	0.73	23	0.82
18	0.83	25	0.77
20	0.73	27	0.85
22	0.96	**Analysis of 25 Results.**	
24	0.87	Mean ...	0.91
26	1.31	Standard Deviation	0.17
28	1.16		
30	0.98	Coefficient of Variation ...	19%

TABLE 5.

Correlation Coefficients for the Daily Figures from four Clones.

Pair of Clones.	Correlation Coefficients.	
	First Period.	Second Period
A44 — B16	+0.63	+0.40
A44 — B58	+0.55	+0.45
A44 — B84	+0.49	+0.24
B16 — B58	+0.57	+0.66
B16 — B84	+0.45	+0.67
B58 — B84	+0.41	+0.66
Number of samples in each clone	37	43

Kuala Lumpur, F.M.S., 31st October, 1932.

NOTE ON THE VARIABILITY OF SHEET PREPARED UNDER LABORATORY CONDITIONS.

BY

J. L. WILTSHIRE.

In the course of work designed to discover means of producing rubber complying with manufacturers requirements, many samples of sheet are prepared under varying conditions. For the proper execution of this work it is necessary to know whether any difference obtained between samples prepared by different methods is significant or whether it can be ascribed to normal experimental variability. The more important type of variability, from this point of view, is the variation occurring in any batch of samples prepared from the same latex. The daily variation of rubber from the same estate is of less importance since controls by a standard method from the same latex are always run against any particular set of conditions.

The standard here adopted is the air-dried sheet prepared by coagulating, in a pan, one gallon of latex of 1½ lbs. D.R.C. with acetic acid. The coagulum is machined 20 hours after the addition of the coagulant and is passed through five machines. The wet sheet is dripped for six hours and is then dried in air at a temperature of 110°—120°F, drying being normally completed in 48 hours.

To reduce the work to reasonable limits the degree of variation amongst a batch of samples is judged by their vulcanising properties only. To permit of a quantitative statement of the degree of variation it is necessary to express these vulcanising properties by one single reliable figure and the figure here employed is that normally used in this laboratory and previously discussed in this Journal. (Vol. III p. 29). Fullerton and Bishop adopted as their standard the tensile modulus of a sample vulcanised under standard conditions at one definite time of cure. The time of cure used for comparison depends on the nature of rubber but the modulus used is always the load in kilograms per square millimetre necessary to produce an elongation of 650 per cent.

The vulcanisation is carried out under the conditions described in the appendix to the paper quoted above and the standard

time of cure for these samples is 80 minutes. The following tables show the results for three batches of sheet prepared on consecutive days. The modulus figure quoted is, in every case, the mean of the results from six rings.

TABLE I.

No.	Modulus in kgs/sq. mm. at 650% Elongation		
	Batch I	Batch II	Batch III
1.	.77	.51	.48
2.	.62	.51	.51
3.	.71	.61	.53
4.	.63	.62	.52
5.	.68	.64	.55
6.	.58	.61	.46
7.	.63	.67	.49
8.	.58	.63	.53
9.	.56	.56	—
10.	.62	.57	—
11.	.67	.57	—
12.	.64	.56	—
13.	.65	—	—
14.	.67	—	—
15.	.70	—	—
16.	.62	—	—
17.	.66	—	—
18.	.60	—	-
19.	.62	—	—
20.	.74	—	—
21.	.62	—	—
22.	.69	—	—
Mean value	.63	.59	.51
Standard deviation	.057	.049	.028
Co-efficient of variation	9.0%	8.3%	5.5%

A further check on the degree of standardisation of the coagulation and machining of such batches of sheet has been obtained from a study of the water content of the machined wet sheet and the area of the finished dry sheet. If the individual pieces of coagulum are identical in physical properties and are subjected to

identical machining treatments then the amount of water remaining in the individual sheets should also be identical throughout. Similarly the area of the dry sheets should also be constant since a constant mechanical treatment is applied to coagula of constant plasticity and hardness.

The table (II) shows the results from 24 coagulations from one batch of latex, under conditions similar to those described above.

TABLE II

Sheet No.	Dry sheet as percentage of wet sheet after 6 hours dripping per cent.	Area of dry sheet sq. inches.
1	93.0	428
2	92.5	390
3	92.6	398
4	93.4	398
5	92.7	390
6	92.6	398
7	93.6	390
8	93.7	398
9	93.8	408
10	94.0	434
11	93.9	420
12	94.4	434
13	94.1	414
14	94.1	432
15	94.5	418
16	94.5	408
17	93.8	432
18	94.5	418
19	94.0	422
20	94.1	414
21	93.7	400
22	93.1	414
23	94.1	424
24	93.2	438
Mean value	93.6	413
Standard deviation	0.63	16
Co-efficient of variation	0.67%	3.9%

Both these figures show a very satisfactory degree of consistency and indicate that the process is standardised as well as can be expected. The area of sheet may be used as indication of the toughness of the coagulum from which it is derived and should be of some assistance to managers who are experimenting with the quantity of coagulant employed in their factories. In practice it is easier and more accurate than a measurement of thickness but to obtain useful comparisons it must be ensured that the sheets are obtained from equal volumes of the same latex.

Kuala Lumpur, F.M.S., 31st October, 1932.

NOTES ON QUEBRACHITOL AND THE LIPIN FROM HEVEA LATEX.

BY

R. M. Woodman and E. Rhodes.

Recent investigations on the non-rubber constituents of latex have centred round two substances in particular, namely quebrachitol & Heavea lipin. Quebrachitol (1) is a white crystalline body. It is extremely soluble in water and possibly because of its sweet taste it has often been mis-described as a sugar. Actually it has a cyclic structure and its chemical designation is l-methyl inositol. Hevea lipin (2) is a fatty complex similar to egg lecithin in that it contains organic phosphorus and nitrogen in combination with fatty acids and glycerol.

In considering possible commercial applications for these latex constituents it was decided to ascertain their value if any in spraying.

Apparent possibilities were the use of the lipin as an emulsifier in the preparation of insecticidal and ovicidal stock (3) emulsions and also its employment as an aid in the preparation of miscible oils (3) : quebrachitol was investigated as an emulsifier, an aid to miscible oil formation, an aid to solution of oils, and as a "wetter" and "spreader" for causing wetting of, and spreading over, the plant, pest and fungoid surfaces, by a spray fluid (4).

Emulsions for spraying are obtained by two methods. First, the manufacturer may sell a non-creaming stock or concentrated emulsion for dilution to the spraying concentration in the field, the emulsion preferably being one which will not interact with the salts causing hardness of natural waters, risks of inversion to the undesirable water-in-oil type thus being avoided (5) ; secondly, the oil and emulsifier may be sold as a solution known as a miscible oil got by the addition of some third substance to the system, the spraying emulsion being prepared in the field by mere stirring into the water.

It has been demonstrated that ovo-lecithin tends with certain oils to the formation of dual types of emulsion (6) i.e., that oil-in-water (OW) and water-in-oil (WO) types of emulsions can be prepared from an aqueous lecithin dispersion and the oil by simply altering the phase volume ratio employed), but also that an emulsifier used in the preparation of spraying emulsions should yeild with the oil, perfect, stable, OW types only (5,7). Any emulsifier,

yielding dual types, therefore, should in general be as rigorously avoided in spraying as one giving the WO type only.

Hevea lipin has been found to give results similar to those with ovo-lecithin. Thus on vigorously shaking together in a closed cylinder the fluid phases 1% aqueous Hevea lipin dispersion and toluene, or chloroform, or carbon tetrachloride, in the ratios 5/15 and 15/5 by volume (ratios which generally allow of the formation of the two types if at all possible (7)), it was demonstrated that dual types were formed, OW with excess aqueous phase and WO when the ratio was in favour of the oil. One important observation which has been found to apply also to certain samples of ovo and soya bean lecithins, was that both types were found to be simultaneously present by drop tests on fresh and aged emulsions and creams (6, 8) with the phase volume ratio in favour of the oil: the aqueous phase disappeared entirely here, the excess continuous phase (9) being oil; the OW type was present in smaller amount as judged by simple tests, and the direction of creaming followed the rules laid down for the WO type (10).

The lipin is, therefore, useless to the manufacturer in the preparation of stock spraying emulsions. At the water-rich ratio, however, the OW types were quite stable and perfect, and hence the lipin could be used providing the grower would make his own emulsion at the place of spraying; such a procedure, however, would be rather rare.

Hevea lipin was now tested as a possible aid in the formation of miscible oils. A solution of 100 gm. of fish oil soft soap containing 34.85%moisture was made in 50 cc of fusel oil by shaking. It was found possible to incorporate with 5 cc of this, 10.55 cc of a special blend of spindle oil before slight turbidity occurred, solutions containing less than this amount of special blend forming perfect, stable, OW types of the special blend on stirring into water. On previous incorporation of Heavea lipin in the fusel oil soft soap solution so that the latter was now 4% as regards lipin, 5 cc of the resulting solution needed 8.55 cc only of special blend to cause turbidity, the presence of the lipin reduced the miscible oil-forming power.

A similar experiment with 5 cc of fusel oil-soap solution 4% as regards quebrachitol (dissolution being effected by long shaking) demonstrated that 8.60 cc of special blend produced turbidity. Here again the added substance lessens the miscible oil-forming tendency of the fusel oil, and hence is useless in this regard.

A 2% aqueous quebrachitol solution was found useless as an emulsifying medium in the preparation of stock emulsions of oils (e.g., toluene, oleic acid & crude soya oil). Neither did this solution dissolve oils (e.g., soya oil & oleic acid).

Quebrachitol has also no value as a wetter and spreader as determined by the tension liquid / air of a solution (4). Thus the drop number at 16°C. of the 2% aqueous solution was 41.8, distilled water having a drop number of 41.7 in the same stalagmometer at the same temperature. It is obvious that quebrachitol does not lower the surface tension of water.

Summary.

Dual types of emulsions are possible with certain oils when the lipin is the emulsifier, and it is noted that with this substance the two types of emulsion can apparently both be present in the same system at one and the same time, the first case of this phenomenon to be recorded up to the present.

Hevea lipin and quebrachitol (1-methyl inositol), two possible by-products from Hevea latex, are demonstrated to be valueless in the spraying industry.

References :

1. Rhodes & Wiltshire : *J. Rubber Res. Inst. Malaya,* 1932, **3,** 160.
2. Rhodes & Bishop : *Ibid.,* 1930, **2,** 125.
3. Woodman : *J. Agric. Sci.,* 1927, **17,** 44 : *Chem. News,* 1926, 133,339; 353; *J. Pomology,* 1925, **5,** 43.
4. Woodman : J.S.C.I., **49,** 93T.; *J. Pomology,* 1924, **4,** 38.
5. Woodman : *J. Physical Chem.,* 1929, **33,** 88; *J. Pomology,* 1928, **6**,313; *J.S.C.I.,* 1930, **49,** 193T.; Woodman & Wiley, *Ibid.,* 1913, **50,** 187T.
6. Woodman : *J.S.C.I.,* 1932, **51,** 95T.; *Chem. Age,* 1931, **25,** 146.
7. Wooman & Taylor : *J.S.C.I.,* 1929, **48,** 121T.; *J. Physical Chem.,* 1930, **34,** 299.
8. Woodman : *Chem. News,* 1932, **144,** 225.
9. Woodman : *J. Pomology,* 1925, **4,** 184.
10. Woodman : *J. Physical Chem.,* 1926, **30,** 658.

Horticultural Research Station, Cambridge Univ., England, & R.R.I. Kuala Lumpur F.M.S. July, 21st. 1932.

PUBLICATIONS.

Publications of the Rubber Research Institute are issued in the following forms:—

(1) *Planting Manuals* appearing at irregular intervals at a price to be fixed for each number.

(2) *Bulletins* appearing occasionally at a price to be fixed for each number.

(3) *Journal R.R.I.* appearing at irregular intervals each year.

All publications will be issued free to those with active rubber planting interests in Malaya.

The following publications have been issued and are obtainable at the prices stated:—

(a) Planting Manuals.

No. 1, "Preparation of Plantation Rubber" by B. J. Eaton ... $2.00

No. 2, "Budding of Hevea in Modern Plantation Practice" by F. Summers ...$2.00

No. 3, "Plantation Sheet Rubber Manufacture" by R. O. Bishop ... $2.00

No. 4, "Latex Preservation and Shipment" by R. O. Bishop and R. G. Fullerton ... $2.00

(b) Journal of the R.R.I., Vol. 1, Nos. 1 and 2 ... ... $1.00
Separate copies of other numbers ... ... (each) 0.50

(c) Annual Reports from 1928 ... ... „ $1.00

(d) Bulletin No. 1.
Natural Coagulation of Hevea Latex by A. S. Corbet $1.00

Bulletin No. 2.
A Study of the effect of Damp Storage on Raw Rubber by B. J. Eaton and R. G. Fullerton $1.00

Bulletin No. 3.
The Root Disease Problem on Old Rubber Areas in Malaya by A. Sharples and A. R. Sanderson ... $1.00

Bulletin No. 4.
Summary of Meteorological Records, Soils Division, by W. B. Haines $1.00

(e) Information Cards, dealing with various phases of Rubber Estate Factory Practice and Defects in Raw Rubber. Cards—free. Loose-leaf stiff cover in which cards are enclosed in Malaya 0.50

outside Malaya $1.00

Bank commission, 29 cents minimum should be added to outstation cheques.